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Report of the Chief

of the

Bureau of Entomology and Plant Quarantine

1948

UNITED STATES DEPARTMENT OF AGRICULTURE
Agricultural Research Administration

LETTER OF TRANSMITTAL

United States Department of Agriculture,
Washington, D. C., September 15, 1948.

Dr. P. V. Cardon,
Agricultural Research Administrator.

Dear Dr. Cardon: I submit herewith a report of the work of the Bureau of Entomology and Plant Quarantine for the fiscal year ended June 30, 1948.

Sincerely yours,

P. N. Annand, *Chief.*

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Report of the Chief of the Bureau of Entomology and Plant Quarantine Agricultural Research Administration, 1948

INTRODUCTION

The new insecticides and new methods of applying insecticides have continued to hold the spotlight in Bureau activities. Several synthetic organic compounds have been tested against many insects, as sprays, dusts, and aerosols, in many formulations and with different kinds of equipment. Various chlorinated hydrocarbons found to have insecticidal value have been compared with DDT. Two phosphorus compounds, tetraethyl pyrophosphate and parathion, have shown considerable promise for many uses. Chlordane, benzene hexachloride, chlorinated camphene, and tetraethyl pyrophosphate are now in commercial use and are recommended for certain purposes.

In laboratory and small-scale field tests parathion has shown outstanding effectiveness against a wide range of insects, but it cannot be recommended for practical use until more is known about its toxicological effects on persons handling it and possible hazards from residues on plants. Several materials have been found which when added to pyrethrum and rotenone increase their effectiveness so that smaller amounts can be used in insecticide preparations.

Gas-propelled aerosols have been improved, both in formulations and in devices for applying them. During the year several formulations suitable for packaging in tin cans under reduced pressure were found to be acceptable under the licensing procedure and appeared on the market. Considerable progress has been made in the development of equipment for applying insecticides by airplane, and important modifications were made to improve mist blowers for applying concentrated sprays.

In addition to research conducted under regular funds, the following new projects were begun during the year with allotments made from appropriations authorized by the Research and Marketing Act of 1946: (1) Virus diseases of stone fruits (insect-vector investigations); (2) effect of insect damage on consumer acceptance in marketing of fruit and vegetables; (3) development and improvement of equipment and companion formulations for effective application of insecticides and fungicides; (4) prevention of insect damage to stored grains, cereal products, and seed stocks; (5) basic research on cotton insects relating to fundamental factors affecting cotton; (6) properties of apiary products as a means of developing new and improved uses; (7) toxicological effects of insecticides on plants and animals; (8) treatment of building materials of agricultural origin to prevent

insect damage; and (9) use of agricultural products as insecticides and accessory materials.

Large-scale programs for the control of insects and plant diseases have been greatly aided by the use of new materials and methods, and several new treatments have been introduced to permit certification of products for movement under plant-quarantine regulations. The problem of protecting our agriculture against foreign pests has continued to increase with the rapid growth of world commerce since the war, and disinsectization treatments have been introduced where feasible to aid in providing better safeguards.

CEREAL, FORAGE, AND RANGE INSECTS

Heavy Losses From European Corn Borer

Losses caused by the European corn borer in 1947 were the highest of record in the United States. Surveys indicated these losses to be about 50,000,000 bushels of field corn, which at prices then current was worth about $94,000,000. The loss in sweet corn was estimated at about $3,000,000. The heaviest losses were in Illinois, Iowa, Minnesota, Indiana, Ohio, Pennsylvania, Maryland, and Wisconsin, in that order. Most of the loss in Maryland was in sweet corn.

The European corn borer is now known to infest corn in 1,052 counties in 28 States. In 1947 it was reported for the first time from 94 counties in 11 States. All but six of these counties were west of the Mississippi River. There were significant decreases in borer population only in North Carolina and New Jersey. General increases occurred in all the western States surveyed, ranging from about 35 percent in Missouri to 50 percent in Illinois, Iowa, and Kentucky, and to the maximum of about twenty-nine-fold in Minnesota. Highest concentrations of borers per 100 stalks were 464 in northeastern Illinois, 469 in eastern Iowa, and 618 in southern Minnesota.

The areas infested by the European corn borer and the southwestern corn borer were found overlapping for the first time in 1947, in Osage and Coffey Counties of northeastern Kansas.

In 1948 DDT was for the first time recommended for the control of the European corn borer on field corn.

Insecticides Absorbed From Soil Kill Borers

European corn borers have been killed by feeding on corn plants grown in soil containing certain insecticides. Ryania and parathion were the most promising of a large number tested in this manner, but the use of insecticides in this way is still in the experimental stage.

In greenhouse tests corn was planted in flowerpots in soil containing 2 grams of the insecticide, and from time to time sections of leaves or stems from the plants were fed to newly hatched larvae in glass vials. Plants grown in soil treated with ryania were lethal to larvae feeding 15 days after the corn was planted, and complete mortality was obtained until after the twenty-fourth day. Plants grown in parathion-treated soil showed appreciable toxicity on the fifteenth day, maximum toxicity on the twenty-first day, and almost none by the twenty-fourth day. The smaller the plants were at the time of treat-

ment the more rapidly did they become toxic. Corn growing in flowerpots became toxic sooner than plants growing in beds. In tests made soon after treatment the stalks often killed larvae when the leaves did not.

In other tests corn plants growing in pots were side-dressed with a suspension of the insecticide. All newly hatched larvae were killed that fed on leaf sections of plants that had been treated with ryania 5 days previously when they were 18 inches high, and the stalks continued to be toxic for 20 days. Leaves from plants treated with parathion when they were 8 inches high began to show toxicity 2 days later, caused complete mortality of borers on the fifth day, with a rapid drop in mortality after the eighth day. The stalks showed some toxicity for 13 days.

Similar tests in the field were less successful, possibly because temperatures were lower. When sections of field plants grown in treated soil were fed to larvae in the greenhouse at higher temperatures, the previous results were duplicated.

Parasites of European Corn Borer and Sweetclover Weevil Imported

To supplement the parasites of the European corn borer already established in the United States, importations were made from France and Italy as follows: 45,550 field-collected larvae of the borer, some of which contained *Apanteles thompsoni* Lyle; 4,686 cocoons of *Campoplex alkae* E. and S.; and 716 cocoons of *Microgaster tibialis* Nees.

Surveys were also made of the natural enemies of the sweetclover weevil. One dipterous and one hymenopterous parasite of the adult beetles were found in France. Small initial shipments of one, *Microctonus aethiops* (Nees), were made to the North Dakota Agricultural Experiment Station for rearing and colonization.

Atomized DDT Protects Corn From Earworm and Fall Armyworm

DDT in white mineral oil applied as atomized sprays has given excellent protection against corn earworms and fall armyworms attacking the ears of hybrid seed corn or sweet corn grown for market or canning. Solutions were the most effective of various formulations tested. Emulsions containing at least 20 percent of oil also gave consistently good control, but those of lower oil content did not penetrate the silk adequately. Some emulsions contained solvents or penetrants that injured the kernels.

A solution of 2.5 ounces of technical DDT in 1 gallon of white mineral oil (85–95 seconds Saybolt viscosity at 100° F.) gave excellent control when applied at rates from 0.5 to 1 milliliter per ear. Another successful formulation consisted of 5 ounces of 50-percent-DDT wettable powder, 20 milliliters of an emulsifier, 1 quart of white mineral oil (same viscosity) with water to make 1 gallon, applied at 2 to 3 milliliters per ear. The spray must be directed toward the silks to cover them completely and penetrate the silk channels.

In most tests good control of both insects was obtained with a single application. The armyworm was more easily killed than the earworm, probably because of its roving habits. Heavy rainfall soon after a treatment helped; the additional moisture apparently aided penetration of the spray.

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New Method for Detecting Weevils in Grain

A new test has been devised by which weevils can be readily detected in grain before it is ground. Heretofore it has not been possible to tell whether grain was infested without cutting open the kernels or examining them under a microscope. Millers might buy No. 1 grade grain that had heavy infestations of the immature stages hidden within the kernels. Such infestations were discovered only after milling, when the finished flour or meal was found to be contaminated with the ground-up insects and their excrement. This new method of detecting hidden infestations consists in treating samples of the grain with a dye containing acid fuchsin. The female weevil drills a hole in a grain kernel, deposits her egg, and then plugs the hole with a jellylike secretion. When grain is soaked in the dye, these plugs become stained. After the grain has been washed, the infested kernels are revealed by cherry-red dots.

This inexpensive and practical method of detection is suitable for determining weevil infestations in wheat, corn, and sorghum grains. Polished rice takes up too much stain to reveal the egg-puncture plugs. It has not yet been tried on other grains. This study is being conducted with funds appropriated under the Research and Marketing Act, in connection with the project on prevention of insect damage to stored grains.

New Treatment for Leafhoppers Increases Yield of Peanuts

For many years fine dusting sulfur has been used to control the potato leafhopper and peanut leaf spot on peanuts in Virginia and North Carolina. Three applications are made 3 weeks apart beginning about July 10–15. This treatment has increased the yield of field-cured peanuts by about 25 percent. It has now been found that when DDT is added to the sulfur 25 to 30 percent more leafhoppers are killed immediately than when sulfur is used alone, and the residual effect of the DDT keeps injurious numbers off the treated vines. A mixture containing 1 percent of DDT, 90 percent of sulfur, and 9 percent of an inert material is satisfactory. DDT residues on the harvested peanuts have been negligible.

Grasshopper Bait Protects Nearly 6 Million Acres

The 1947 grasshopper-control program gave protection to more than 5,698,000 acres of crops and pasture, valued at about $50,369,000. Savings amounted to almost $53 for each dollar spent by the cooperating county, State, and Federal agencies. An estimated 2,160,000 acres of lands were baited in 23 Central and Western States. More than 20,600 farmers and ranchers in 409 counties participated in spreading 11,072 tons (all figures dry weight) of sodium fluosilicate bait furnished by the Federal Government The Bureau financed the spreading of an additional 1,231 tons in Colorado, Idaho, Kansas, Montana, Nebraska, South Dakota, and Wyoming. These operations were conducted along 19,094 miles of roadsides and in other habitats such as grasshopper egg beds, railroad rights-of-way, and idle lands. Other Federal agencies spread 63 tons on lands under their jurisdictions.

Surveys conducted during the fall of 1947 indicated that the in-

festation to be expected in 1948 would be slightly more extensive than that which developed in 1947. An adult survey was made in 877 counties in 23 States, and an egg survey in 583 counties in 16 States. There was an apparent upswing in the importance of *Melanoplus mexicanus mexicanus* (Sauss.) in eastern Colorado, western Kansas, several areas in Montana east of the Rocky Mountains, the Panhandles of Nebraska and Oklahoma, southwestern South Dakota, the northern part of the Texas Panhandle, and much of eastern Wyoming.

The amount of bait used in 1948 is expected to exceed the 12,366 tons spread in 1947, provided weather conditions are favorable for grasshopper development, crop growth, and baiting activities, and provided further that the newer insecticides do not materially affect the use of bait. By June 19, 3,240 tons of bait had been mixed in all States, almost twice the amount that had been mixed at the same time in 1947.

New Sprays and Dusts for Grasshopper Control

Grasshoppers can be controlled with sprays and dusts containing chlorinated camphene or chlordane. Benzene hexachloride is also effective, but it has given less dependable results. When sprays are used, 1 pound of chlordane, 1½ pounds of chlorinated camphene, or 4 pounds of benzene hexachloride (10 percent gamma) should be applied per acre. For dusts the dosages should be increased to 1½ pounds of chlordane, 2 pounds of chlorinated camphene, or 5 pounds of benzene hexachloride. Late in the season, when there is a heavy growth of marginal vegetation and most of the grasshoppers are adult, a slight increase in the dosages of both dusts and sprays may be necessary.

Under some conditions these materials have given quicker control and continued to kill longer than the poisoned bait that has been in general use for grasshopper control in recent years. They are effective for one to several weeks, depending on the weather, the vegetation, the season, the age of the grasshoppers, and to some extent on the chemical and formulation used.

The sprays and dusts are suitable for the control of grasshoppers occurring in tall, succulent growth along roadsides, canal banks, and field margins, or in rank-growing alfalfa, young cotton, flax, or corn. For grasshoppers on range, idle lands, in small grains, or in field margins or other locations where vegetation is sparse, the standard sodium fluosilicate bait is more practical.

On account of the residues likely to be present, vegetation treated with these sprays or dusts should not be grazed by or fed to dairy animals or to meat animals that are being fattened for slaughter.

Most Mormon Cricket Infestations Remote From Crops

In 1947 Mormon cricket infestations in the Western States developed about as indicated by the 1946 surveys. The infested acreage, 586,000 acres, was almost twice that in 1946, but most of the infestations were fairly remote from croplands. The Federal Government financed baiting in 13 counties in Idaho, Nevada, Oregon, and Washington, the work being undertaken in cooperation with the States. Bureau crews spread 1,271 tons (dry weight) of bait, and other Federal agencies, ranchers, and farmers spread 395 tons. Almost 258,000 acres were

baited in the combined operations to protect 151,000 acres of croplands, as well as large areas of pasture and range. Mormon crickets damaged 29,000 acres of crops and 347,000 acres of range. Most of the control was accomplished on range infestations distant from cultivated areas. About 98 percent of the bait was spread with ground baiting equipment and the remainder by airplane.

Surveys made late in the summer of 27 counties in 5 States indicated that the acreage infested in 1948 (536,000 acres) would be slightly less than in 1947. By June 19, 1948, Bureau crews had spread 1,057 tons of bait on 125,000 acres of lands in Idaho, Oregon, and Washington, and farmers, ranchers, and other cooperators had spread an additional 117 tons on 12,960 acres.

Chinch Bug, Armyworm, and Army Cutworm Populations Low

Chinch bug incidence in the normally infested Central and Midwestern States was very low during 1947. Seventy-six farmers in 17 counties in Kansas, Missouri, and Oklahoma erected and maintained 6,500 rods of barrier, using 4,900 gallons of creosote oil furnished by the Federal Government. These operations protected 1,600 acres of crops valued at about $14,000.

Fall and early winter surveys conducted in 205 counties in 7 States indicated that, unless the weather in the spring and summer was unusually hot and dry, chinch bug populations would continue to be light during 1948. Only in northeastern Oklahoma was there a decided increase in numbers of the insect. By June 19 farmers in scattered areas of eastern Kansas and northeastern Oklahoma had used small quantities of federally provided creosote oil, and control work was expected to be continued in this area until about July 1.

During 1947 armyworms and army cutworms required control in only a few localities in 14 counties in 6 States. Fifty tons of bait were spread on about 5,600 acres of crops and pasture by 125 farmers. In the spring of 1948 infestations requiring a small amount of control were found in scattered localities in Arkansas, Illinois, Iowa, Missouri, Montana, Nebraska, and Utah.

COTTON INSECTS

New Insecticides for Control of Cotton Insects

In November 1947 Federal and State workers concerned with cotton-insect control in the Southeast, and also in Texas and Oklahoma, held a conference at Stoneville, Miss., to bring together the results of their research, especially with new insecticides, during the 1947 season. In April 1948 a similar conference of entomologists in the Southwest was held at Phoenix, Ariz.

After reviewing and summarizing their experiments and experiences, these workers formulated statements to serve as a guide for general control recommendations in 1948. This information was believed to be of value to the insecticide industry in planning production programs and to cotton growers who might be contemplating the use of some of the insecticides that are still in the experimental stage. A brief summary of current information on the use of insecticides for the control of each of the important insect pests of cotton is given in the following paragraphs.

Boll Weevil

Calcium arsenate, benzene hexachloride, chlorinated camphene, and chlordane have proved effective for controlling the boll weevil. When some of these insecticides were used alone for boll weevil control, injurious infestations of aphids and some other cotton insects developed. For general use on farms the following mixtures have been found satisfactory: Calcium arsenate plus 1 to 2 percent of nicotine; a dust containing 3 percent of the gamma isomer of technical benzene hexachloride, 5 percent of DDT, and at least 40 percent of sulfur; and a dust containing 20 percent of chlorinated camphene and 40 percent of sulfur. The organic insecticides should be applied at the rate of 7 to 10 pounds per acre. From 5 to 10 pounds per acre is the usual dosage for calcium arsenate.

In experiments in several States dusts containing 10 percent of chlordane or 5 percent of the gamma isomer of technical benzene hexachloride gave boll weevil control equal to that given by calcium arsenate, prevented build-up of aphids, and killed some weevils developing in fallen squares.

Bollworm

In 1946 and 1947 the bollworm was more widespread and important as a pest of cotton than in other recent years. The outbreaks were due in part to changes in cropping systems. The acreage of cotton has been reduced and that of other crops that are hosts of the bollworm, such as alfalfa, corn, sorghum, and soybeans, has been enlarged. At times these other crops serve as important hosts to increase bollworm populations on cotton. The use of certain insecticides is often followed by an increase in aphids, and their secretion of honeydew attracts bollworm moths. The aphids also serve as food for predators that would otherwise consume bollworm eggs. Some insecticides are especially detrimental in killing natural enemies of bollworms.

Several insecticides have been found to control the bollworm. A choice may therefore be governed by such other factors as availability, cost, and abundance of associated pests. The most effective materials were 20-percent chlorinated camphene, 5-percent DDT plus 3-percent gamma benzene hexachloride (as technical benzene hexachloride), and 10-percent DDT. Less effective materials were 5-percent DDT, calcium arsenate, lead arsenate, and cryolite. Where it is necessary to control spider mites, the dust should contain at least 40 percent of sulfur. When DDT is used without benzene hexachloride, a higher percentage of sulfur (at least 70 percent) will aid in suppressing aphids.

All dusts should be applied at the rate of 10 to 15 pounds per acre, the amount depending on the intensity of the infestation and the size of the cotton plants. Applications should begin when 4 or 5 bollworms are found per 100 terminals and should be repeated every 5 days until the infestation is controlled.

Successful control of the bollworm is dependent upon the timeliness of the application and thorough coverage of the plants throughout the period of injurious infestation.

Cotton Aphid

Heavy aphid infestations often follow the use of certain insecticides for the control of other cotton insects. On fruiting cotton they seldom

occur except under such conditions, but seedling cotton is frequently infested.

Calcium arsenate plus nicotine, 2 percent in alternate applications or 1 percent in all applications, was found to prevent aphid build-up in some areas. A calcium arsenate or lime dust containing 3 percent of nicotine controlled heavy infestations of aphids.

Technical benzene hexachloride applied at the rate of one-third pound of the gamma isomer per acre prevented aphid increase, and at the rate of one-half pound per acre knocked out heavy infestations of aphids. The mixture of benzene hexachloride and DDT found effective for boll weevil and bollworm control gave results equal to those obtained with benzene hexachloride alone for cotton aphid control.

In some localities the effectiveness of benzene hexachloride against the cotton aphid varied with the time of day that it was applied. In some experiments in Mississippi almost twice as much of the gamma isomer was required in early-morning as in late-evening applications, when concentrations of 1 to 3 percent were used. The difference in control was attributed to wind and convection currents. It has therefore been recommended that more attention be paid to the timing of all insecticide applications for control of cotton aphids.

Hybridization studies in 1947 gave further encouragement to the possibility of developing a variety of cotton that is resistant to aphids and at the same time of high quality and adapted to mechanical picking. Previous studies had shown that glabrous, or smooth-leaf, strains were more resistant than hairy strains, and it has now been found that superior grade qualities can be transmitted from glabrous parents to glabrous offspring.

Pink Bollworm

DDT is the most effective insecticide that has been found for the control of the pink bollworm. It is generally used as a 10-percent dust. Technical benzene hexachloride may be added to prevent aphid build-up and also to control the boll weevil and stinkbugs. A mixture containing 10 percent of DDT with 2 percent of the gamma isomer of benzene hexachloride or 5 percent of DDT with 3 percent of the gamma isomer may be used. Sulfur is the preferred diluent, as it controls spider mites. All these dusts should be applied once a week at the rate of 15 pounds per acre.

Cultural practices are still considered to be the best method of controlling this pest.

Cotton Fleahopper, Tarnished Plant Bug, and Rapid Plant Bug

All the new synthetic organic insecticides that have been adequately tested have given effective control of the cotton fleahopper, and usually of the tarnished plant bug and the rapid plant bug. Considering the many factors involved, such as cost, availability, and effectiveness for other cotton insects, the following materials are preferred: Chlorinated camphene 10 percent, DDT 5 percent, and technical benzene hexachloride containing 3 percent of the gamma isomer. The DDT dust usually contains 75 percent of sulfur, the other materials 40 percent. Sulfur alone and a 2-to-1 mixture of sulfur and calcium arsenate will also control these insects. Both chlordane and parathion have given good results, but more extensive experiments are necessary before recommendations can be made for their use.

Cotton Leafworm

For many years calcium arsenate, paris green, and lead arsenate have been used for control of the cotton leafworm. Where a dust containing 20 percent of chlorinated camphene, 3 percent of the gamma isomer of technical benzene hexachloride, or a mixture of 5 percent DDT and 3 percent of the gamma isomer of technical benzene hexachloride has been used for control of other cotton insects, it has also controlled the cotton leafworm. Other materials that were highly toxic to this insect in cage tests during 1947 were parathion 2 percent, TDE 10 percent, and methoxy analog of DDT 10 percent.

Spider Mites

Spider mites often increase following the use of certain insecticides for control of the boll weevil and other cotton insects, probably as a result of the destruction of natural enemies of the mites. Sulfur at the rate of 15 to 20 pounds or more per acre is recommended for the control of these mites. Dust mixtures of organic insecticides used against other cotton insects should contain at least 40 percent of sulfur to prevent increases of spider mites. Laboratory and field tests indicate that a 1-percent parathion dust is effective against these mites.

Stinkbugs

Several species of stinkbugs—principally the conchuela, Say's stinkbug, and the brown bug *Euschistus impictiventris* Stål—attack cotton in the irrigated sections of the Southwest. The species vary from year to year and from section to section. These insects not only are capable of causing serious losses in yields but can materially reduce the quality of cotton.

DDT, while of some value, has not proved entirely satisfactory as a control measure. Two dusts containing technical benzene hexachloride have proved effective. One contains 5 percent of DDT plus 2 percent of the gamma isomer plus 40 percent of sulfur, and the other 3 percent of the gamma isomer plus 50 percent of sulfur. A dust mixture containing 20 percent of chlorinated camphene and 40 percent of sulfur also shows promise. The dust should be applied at the rate of 15 to 20 pounds per acre. A benzene hexachloride spray applied at the rate of 4 gallons, or 0.4 pound of the gamma isomer, per acre has also given control. Applications of the insecticides should be begun when 5 or 6 stinkbugs are found per 100 plants.

Pink Bollworm Quarantine Activities

The pink bollworm quarantine was amended August 22, 1947, to remove the quarantine from Louisiana, to place Hockley and Wharton Counties of Texas under quarantine, and to transfer Starr County of Texas from the heavily infested to the lightly infested area. The quarantine was again amended, effective June 11, 1948, to include territory in Texas and Oklahoma found infested in the fall of 1947. This is the first time any part of Oklahoma has been quarantined because of the pink bollworm. Administrative instructions were issued to reimpose in a number of counties treatment requirements on interstate movements of baled lint, and to authorize additional methods of treating cottonseed for certain areas.

Inspection of the 1947 cotton crop revealed light infestations in 40 counties not under quarantine. One of these counties, Roosevelt

County in New Mexico, had been released from quarantine after several years of negative findings. Infestations in four counties in southwestern Oklahoma were the first recorded for that State. The remaining 35 counties were in Texas, most of them north of the regulated area in the Panhandle. One county, Bexar, adjoins the regulated area in southern Texas. Inspections in 57 other counties of Texas showed negative results, as did inspections in 12 counties of Alabama, 7 of California, 5 of Florida (on domestic cotton), 24 of Georgia, 16 of Louisiana, and 17 of Oklahoma.

Within the regulated areas infestation was lighter than normal in Hidalgo, Cameron (with the exception of the Brownsville area), and Willacy Counties in the lower Rio Grande Valley. This reduced infestation was reflected in lighter than normal findings in all the coastal counties except Nueces and San Patricio. A spectacular build-up in a new cotton area just over the border in Mexico in 1947 resulted in an influx of moths to fields of Starr, Jim Hogg, Zapata, Zavala, Duval, and Webb Counties of Texas. An intensive DDT dusting program apparently cleaned up infestations in Refugio and Calhoun Counties, which were very heavy in 1946. No pink bollworms were found northeast of these counties, but considerable numbers were found in Howard, Midland, Martin, and Tom Green Counties. Infestation was much lighter than last year near Presidio and in the El Paso Valley and also in the New Mexico valleys. In Arizona the insect was found only in Graham County, the infestation being very light.

In the 1947 crop season 27,400 bushels of gin trash were inspected in regulated areas of Texas, Arizona, and New Mexico. About 25,000 pink bollworms were found, nearly all of them in Texas. In the field 3,500,000 bolls, blooms, and squares were inspected in Arizona and Texas, and 10,000 pink bollworms were found, all in Texas. In addition, 14 Thurberia weevils were found in inspection of gin trash and bolls in Arizona.

Inspection of nearly 45,000 bushels of gin trash from areas outside regulated territory in Alabama, California, Florida (domestic cotton), Georgia, Louisiana, New Mexico, Oklahoma, and Texas yielded 76 pink bollworms—4 from New Mexico, 6 from Oklahoma, and 66 from Texas. Inspection of about 19,000 bolls, blooms, and squares in fields of Oklahoma and Texas disclosed 10 pink bollworms, all in Texas.

The highly effective clean-up program that has been conducted in the lower Rio Grande Valley since 1945 was continued during 1947, but the period for harvesting was extended through September 13, because of heavy rains attendant on a hurricane in early August. Formerly under this program growers had been required to destroy all cotton stalks by August 31 and subsequently to maintain their land in a host-free state until the next planting season. Except for 2 weeks' extension of the deadline, satisfactory conditions prevailed for securing a host-free condition in southern Texas.

Early in June 1948 funds were made available for the procurement of 300,000 pounds of dust containing DDT, benzene hexachloride, and sulfur for use against early-developing heavy infestations along the Mexican border in both the United States and Mexico, to prevent spread of the pink bollworm into noninfested areas of the United States.

More than 2,767,000 bales of cotton, including 1,500 that received roller treatment, were ginned under dealer-carrier permit in Texas, New Mexico, Arizona, Louisiana, and Oklahoma. Over 1,000,000 tons of seed were given one heat treatment, 45,000 tons were given a second heat treatment, 5,000 tons were processed at oil mills and heat-treating plants, and 1,150,000 bales of linters were subjected to compression. About 17,000 bales of lint and 3,500 bales of linters, including mill waste and bagging from Mexico, were vacuum-fumigated.

All cottonseed in the possession of growers in nine counties in Texas and eight counties in Oklahoma, totaling more than 5,000 tons, was heat-treated, in cooperation with the States. In addition commercial breeders and seed dealers in the newly infested areas treated nearly 9,000 tons of planting seed.

Transit inspectors reported 144 shipments of restricted products coming out of infested areas in Oklahoma, New Mexico, and Texas. A number of uncertified shipments of cottonseed and contaminated cotton-picking sacks from the newly infested area were intercepted. At the 3 stations maintained to inspect highway traffic from the quarantined area in the lower Rio Grande Valley, 412,019 cars and trucks were inspected, and 4,010 found carrying contraband material.

Cooperative work with Mexico was continued during the year. Although the principal cotton-growing area in Mexico, the Laguna area, is some distance from the border, the extensive acreage in cotton and the intensity of infestation make it the largest reservoir of pink bollworms in North America, and control of the insect in that area is of considerable importance to cotton growers in the United States. In recent years there has been a large increase in cotton acreage near Matamoros, Tamaulipas. Thousands of new farmers wholly unfamiliar with pink bollworm problems of the area have moved there to grow cotton. The stalk-destruction and clean-up programs in both these areas have reduced incidence of stub cotton considerably, and thereby increased the efficiency of the host-free period. Fixed planting and stalk-destruction dates in the Matamoros area to conform to those applicable in the adjacent lower Rio Grande Valley of Texas were again enforced by the Mexican authorities.

FRUIT INSECTS

Codling Moths Controlled With Fewer DDT Sprays

The widespread use of DDT for codling moth control has reduced populations of this pest. Consequently fewer applications are now required to give satisfactory control. In New York, for example, nearly 100 percent of the fruit in a large block was clean after three applications of DDT in 1947, whereas four applications were needed in 1946, and five in 1945.

In West Virginia a three-cover DDT schedule was almost as effective as a four-cover schedule. In the Pacific Northwest three covers are now the rule rather than the exception. In Washington the calyx spray was omitted in DDT-sprayed blocks without loss of effectiveness. In Indiana it was possible to reduce populations to such a low point with several first-brood DDT sprays that only a very light second-brood program was needed. Ordinarily heavy second-

brood spray programs are employed in this area. Weather conditions were unfavorable to the codling moth during the last three seasons, but the reduction in number of sprays is believed to be due chiefly to the general adoption of DDT.

The trend to fewer sprays for codling moth control has been partly offset by the need of additional sprays for such other pests as mites and the woolly apple aphid, which have increased to higher than normal levels in many DDT-sprayed orchards, perhaps because of the killing of their natural enemies by DDT. However, the net result has been a distinct gain for most growers through a reduction in pest-control costs.

New Insecticides for Fruit and Nut Insects Tested

In the hope of finding materials that would control some of the more important fruit and nut insects and mites as well, tests were made with several new organic insecticides. The results of these tests are indicated in the following paragraphs, but further study is necessary before they can be recommended for use.

Apple Insects

Parathion was very effective against the codling moth and the red-banded leaf roller on apple, when used in sprays containing 3 to 4 pounds of a 15-percent wettable powder per 100 gallons. Its use for control of mites is discussed elsewhere. In Washington chlorinated camphene showed promise for use in combination with DDT. A light codling moth infestation in West Virginia was controlled with TDE.

In Washington the woolly apple aphid was killed with benzene hexachloride, but apples sprayed with this insecticide in mid-August were off flavor when harvested late in October. This objectionable taste was more pronounced when the spray mixture contained oil. Sprays containing tetraethyl pyrophosphate also showed promise against this aphid, but they were less effective than benzene hexachloride.

Pear Psylla

In Washington complete control of the pear psylla was obtained with parathion, ½ to 1 pound of a 15-percent wettable powder in 100 gallons of water, and there was no appreciable recurrence of the infestations for at least 23 to 27 days. Benzene hexachloride was also effective when 1½ pounds of a wettable powder containing 5.7 percent of the gamma isomer was used with oil in 100 gallons. This spray caused no foliage injury and did not affect the flavor of the fruit when applied before July 1.

Tetraethyl pyrophosphate and chlorinated camphene also gave high immediate kills of pear psylla nymphs in the States of Washington and New York. The pyrophosphate lacked residual value and injured the pear fruit and foliage. Deposits of chlorinated camphene prevented marked increases in infestations for long periods. Chlordane was less promising than other materials against this insect.

Insect Pests of Stone Fruits

In cage tests plum curculio adults on peach were killed in 2 to 5 days by parathion in sprays containing ½ to 2 pounds of the 15-percent wettable powder in 100 gallons, and the 2-pound strength gave a high

kill of adults placed in the cages 2 weeks after the spray had been applied.

In orchard tests in Georgia peach trees sprayed with benzene hexachloride had fewer premature drops and smaller percentages of plum curculios in the drops than trees receiving the standard lead arsenate treatment. The trees treated with benzene hexachloride consequently had a larger crop of peaches, but this material appeared to be no more effective than lead arsenate in protecting the fruit on the trees at harvesttime from curculio injury. In four applications, the last one 4 weeks before harvest, the material caused no injury and did not affect the flavor of the fruit.

Tetraethyl pyrophosphate and chlorinated camphene gave immediate kills of the plum curculio, but neither of these materials had the residual value of parathion, and the pyrophosphate injured peach foliage. Chlordane gave promising results against overwintering curculio adults, but was less effective against first- and second-brood adults.

The green peach aphid was controlled with parathion spray, 1 pound of a 15-percent wettable powder in 100 gallons, and the black peach aphid with a dust containing 0.25 percent of parathion. Benzene hexachloride was also effective against both these aphids. In Oregon tetraethyl pyrophosphate was highly toxic to the black peach aphid, and in Washington it showed promise against the green aphid.

Benzene hexachloride also killed climbing cutworms and sucking bugs on peaches, but was less effective than DDT on sucking bugs.

Pear thrips on prunes in Oregon were greatly reduced with 0.25-percent parathion dust and also with 2-percent chlordane dust.

Against the oriental fruit moth TDE was about as effective as DDT, but chlordane was less satisfactory.

Citrus Pests

Parathion gave outstanding results against several insect pests of citrus fruits. In Florida one treatment with an emulsion of this insecticide gave better control of the purple scale and the cloudy-winged whitefly than two applications of 1-percent summer-oil emulsion. A mixture of parathion and wettable sulfur was also effective against these insects, as well as the rust mite and the red mite on citrus. In California spray emulsions of parathion in organic solvents and a parathion wettable powder were toxic to mature California red scales, seemed to hinder reproduction by surviving scales, and had considerable effect on crawlers produced by them. A spray containing 4 pounds of a 15-percent parathion wettable powder per 100 gallons was as effective against the scales as a standard oil spray and had a residual effect for 29 days. The material was also superior to nicotine sulfate against the citrus thrips in California.

Against the little fire ant on citrus trees in Florida, chlorinated camphene and chlordane were both as effective as DDT.

Grape Leaf Folder

In California the grape leaf folder was controlled with a sulfur dust containing 1 percent of parathion and also with a dust containing benzene hexachloride.

Pecan Insects

In late-season tests against the black pecan aphid in Louisiana, dusts containing 1 and 5 percent of parathion were very effective.

Benzene hexachloride was also promising when applied as an aerosol or in a dust containing 3 percent of the gamma isomer and 20 percent of sulfur. Tetraethyl pyrophosphate, applied in a spray or a heat-generated aerosol, was about as effective as nicotine sulfate with summer oil. Benzene hexachloride also reduced by about two-thirds injury to pecans caused by the shoot curculio *Conotrachelus pecanae* Buch. The pecan weevil was less affected by chlorinated camphene and chlordane than by DDT.

Effect on Parasites and Predators

The effect of some of the new insecticides for codling moth control on the natural enemies of other pests of apple, including two species of spider mites and the woolly apple aphid, was studied in orchards in Washington. In orchards treated with DDT a predator on mites, *Stethorus punctum* Lec., and a parasite of the woolly aphid, *Aphelinus mali* Hald., were practically eliminated and mite and aphid infestations built up rapidly, whereas both these beneficial insects were abundant after applications of cryolite. A predaceous mite, *Seuilus* sp., increased more slowly after treatment with DDT than when cryolite was used. Results with hexaethyl tetraphosphate were similar to those with DDT. These new insecticides must therefore be applied more often to compensate for the reduction of natural enemies.

Progress in Control of Orchard Mites

The problem of orchard mites has increased in importance, presumably because their natural enemies have been destroyed by the DDT now widely used to control other orchard insects. Consequently, greater attention was given during the year to the development of more satisfactory methods of controlling mites.

Parathion has given especially favorable experimental results. In Washington, Indiana, and West Virginia good control of the common mites on apples was obtained with as little as one-fourth to one-half pound of a 15-percent parathion wettable powder per 100 gallons of spray. One pound per 100 gallons of the same formulation held the European red mite in check for 2 to 7 weeks. In Indiana a single late-summer application showed promise of greatly reducing the carry-over of European red mite eggs. A spray containing one-half pound of this wettable powder in 100 gallons nearly wiped out a heavy infestation of the Pacific mite in Washington, and the mites did not reappear for 1 month.

Various species of mites on citrus were controlled with parathion sprays. Against red mites and rust mites in Florida both a mixture of parathion and wettable sulfur and a parathion emulsion were effective, but the emulsion delayed the build-up of these mites for a longer period. In California 4 pounds of 15-percent parathion wettable powder per 100 gallons showed promise for controlling the citrus red mites and caused only minor injury to the foliage of lemon trees.

Parathion, in a spray containing 3 pounds of 15-percent wettable powder per 100 gallons, was the most toxic material tested against a *Tetranychus* mite on pecan.

In 1947 parathion did not injure trees or fruit to which it had been applied, or affect the men who handled it, with minor exceptions.

Residues on fruit, when measured, weathered to a low point, usually less than 1 part per million, within 2 weeks after the final application. In the spring of 1948 both the fruit and the foliage of certain apple varieties showed some injury when parathion was combined with sulfur in a spray.

Another compound, bis(*p*-chlorophenoxy)methane, gave high kills of all species of mites on apples and showed considerable residual value. It caused no injury to the trees in West Virginia, but russeted fruit in Indiana and Washington. In Ohio this material was also effective against the European red mite on peaches. In Florida bis(*p*-chlorophenoxy)methane was toxic to mites on citrus without causing noticeable injury to the trees.

Tests with hexaethyl tetraphosphate, which showed promise for mite control in 1946, and its active ingredient, tetraethyl pyrophosphate, gave variable results in 1947. These phosphates are highly toxic to the active stages, but are not effective against the eggs. Repeated applications are necessary, since they have little residual value. In Indiana tetraethyl pyrophosphate caused severe injury to fruit and foliage when applied as a concentrated mist. Sprays coming in contact with the eyes of persons caused the pupils to contract, greatly reducing vision under artificial light for several days.

An emulsion of 1,1-bis(*p*-chlorophenyl)ethanol was highly promising against the Pacific mite on apples in Washington.

A widely used commercial product containing the dicyclohexylamine salt of dinitro-*o*-cyclohexylphenol again gave fairly good control of mites. In Washington, however, five applications were required on apples in 1947, although two had been sufficient in previous years. On grapes three-fourths pound per 100 gallons gave good control without injuring the foliage.

Pear Psylla Control Project Discontinued

The pear psylla control project in the Northwest was discontinued at the end of 1947. This project had been under way since 1940.

The pear psylla was found in the Spokane Valley in the summer of 1939, the first known occurrence west of the Mississippi. Because of its destructiveness in the Northeast, the Washington State Horticultural Association and the Washington State Department of Agriculture urged the Bureau to cooperate in an effort to eradicate the pest from the Northwest, or at least to prevent its spread to the important pear-producing areas of the West. During 1940 and 1941 numerous additional infestations were found in Chelan, Okanogan, and other counties in Washington. In 1942 the insect was found in the Okanagan Valley in British Columbia. From that time until 1946 the infested area increased very little, and in some parts, notably Spokane County, the number of infestations was considerably reduced. During this period the objective of the program was to protect the main commercial areas, which in general were uninfested.

Intensive surveys late in 1946 and during the winter and early spring of 1947 revealed a considerable number of infestations throughout the Wenatchee Valley, and 8 at scattered points in the Yakima Valley. The program for 1947 was therefore modified and reduced. The limited survey that was carried on in 1947 revealed 13 new infestations in the Yakima Valley and 40 in the Wenatchee area. On

numerous previously infested Wenatchee properties the number of psyllas increased markedly.

Since the insect has now established itself in important pear-producing areas of the Northwest, it was decided that the cost of control would not be justified, and the program was discontinued. Although the insect was not eradicated from the Northwest, its spread to other important pear-producing areas of the West was undoubtedly delayed for several years.

Hall Scale Fumigation Program Expanded

The fumigation program in the Hall scale control project, which is carried on in cooperation with the California State Department of Agriculture, was expanded during the winter of 1947–48. For the first time all known infested trees in the Chico and Oroville areas, including all susceptible stock in the Federal Plant Introduction Garden, were fumigated in the same season. The results of these fumigations cannot be finally determined until later, but spot inspections have failed to reveal any living scale thus far.

A less favorable development was the discovery of a Hall scale infestation in October in the orchard of the California Agricultural Experiment Station at Davis. No fumigation has yet been done there, but most of the heavily infested trees have been destroyed, and adequate safeguards have been instituted by the California authorities to prevent the movement of infested plant material from the orchard. Properties on which nursery stock from the orchard was planted are being inspected as rapidly as possible. An extensive planting at Winters, Calif., which was made largely with stock from the Davis orchard, has been gone over carefully. Thus far there has been no indication of spread from the Davis orchard.

Citrus Blackfly Moving North in Mexico

The finding of an infestation of the citrus blackfly in Empalme, Mexico, in June 1947 caused considerable concern to the citrus industry of the Southwest. Empalme is on the west coast in the State of Sonora, about 260 miles from our border, and the next railroad division point south of Nogales, Ariz. The Bureau, with the assistance of the citrus industry, the State of California, and the Mexican Government, conducted a survey late in the summer to appraise the blackfly situation in Sonora with regard to the extent and intensity of the infestation and the hazard of further northward movement.

Infestation was found to be general in several towns along the railroad south of Empalme, and very heavy in some places. Light to medium infestations were found in Empalme and in Guaymas nearby. Eighteen commercial citrus groves, with more than 22,000 citrus trees and 173,000 nursery trees, are located near the village of San Jose de Guaymas, about 6 miles northwest of Empalme. Light but scattered infestations were found in eight of these groves. No infestation of the blackfly was found north of this area. However, it has gained a foothold in the State of San Luis Potosi near Yahhes, where the Mexican Government has undertaken a program of suppression.

The survey covered 339 properties having about 128,000 trees and 234,000 nursery trees. The infestation was confined principally to

citrus. The survey indicated that the spread in Sonora was primarily by railroad. The recent completion of a new rail line has increased the hazard of spread toward the Arizona and California border. The infested area now extends along the west coast of Mexico for more than 800 miles.

Because this infestation in Mexico is a serious threat to the citrus industry in the United States, special funds have been appropriated for expanding and intensifying investigations on the citrus blackfly, in cooperation with the Mexican Government and affected citrus growers in that country. Under this program research is being conducted to obtain more effective control by the use of insecticides, and large-scale tests are being made to demonstrate to Mexican growers the value of using insecticides to protect their crops. A search is also being made for natural enemies that may aid in control under conditions in Mexico, because parasites that hold the insect down in Cuba and some other places have been of little value where distributed in Mexico.

Tests at the Mexico City laboratory of the Bureau indicate that the blackfly could survive in any latitude where citrus is grown. Immature stages on citrus seedlings withstood 6 hours' exposure to 24.8° F., the lowest temperature that did not cause defoliation of the seedlings.

In-Transit Refrigeration to Prevent Introduction of Fruit Flies

The treatment of fruit known to be infested with the Mediterranean and other fruit flies by refrigeration while en route to this country attracted increased interest during the year. The fruit is kept under refrigerator storage while in transit, with provisions that stipulated maximum temperatures, below which all the flies are killed, shall not be exceeded and that automatic continuous temperature records be maintained. During 1948 several ships were authorized to apply this treatment while en route between South Africa and New York, so that now 13 vessels are equipped with temperature-recording equipment as required by this Department.

The Argentine Government requested that similar arrangements be made to treat fruits that had been quarantined after the 1947 shipping season because the Mediterranean fruit fly had been discovered in new areas in that country. Two representatives of the Department were sent to Argentina to survey facilities and work out arrangements for treatment while in transit. Since dockside precooling facilities were not immediately available, these representatives supervised the treatment of some fruit in Argentine cold-storage plants before it was shipped to the United States.

Planes From Hawaii Treated to Protect Mainland From Oriental Fruit Fly

The oriental fruit fly (formerly known under other names such as the mango fruit fly and the Formosan fruit fly), which was discovered in Hawaii in 1946, has spread rapidly until it is now the major insect problem on these islands. Not only does the presence of this fly prevent the production of sufficient quantities of the common fruits—such as papaya, avocado, orange, and mango—even for local consumption, but it is a menace to the fruit industry of the continental United States because of the risk of entry, especially by air transportation.

This new problem has emphasized the importance of inspection and treatment of all planes both upon arrival in and before departure from Hawaii. Aerosols now in use are not completely satisfactory, and several new formulations are being tested. An aerosol is needed that will have the maximum killing power and will at the same time be harmless to fabrics, surfaces, and equipment of the plane and not seriously objectionable to the passengers.

At the Honolulu laboratory it has been found that vapor-heat sterilization of papayas, with 8 hours' approach and 8¾ hours' exposure at 110° F., all in water-saturated atmosphere, will prevent the fruit from carrying infestation.

Mexican Fruit Fly Quarantine Activities

Only 253 infestations of the Mexican fruit fly were found in the regulated area in Texas during the spring of 1948. The flies were somewhat late in appearing this season, but after they began laying eggs infested fruit was plentiful and it became necessary to sterilize all grapefruit harvested for shipment after April 23. Sterilization at high temperatures was conducted in 28 packing houses. During the season approximately 200,000 tons of grapefruit were treated in this way. No oranges were sterilized, nor was any fruit subjected to low-temperature sterilization.

Revision of the quarantine regulations again permits the movement of citrus fruit from the regulated area without the use of shipping tags or master permits until trapping indicates the presence of gravid flies in the groves.

For the first time Texas fruit was permitted entry into the State of California. Shipments of grapefruit to California markets were made during March after the fruit had been sterilized under the supervision of this Bureau and had been treated for scale insects under the supervision of the Texas Department of Agriculture.

TRUCK CROP AND GARDEN INSECTS

New Aerosols Control Greenhouse Pests

An aerosol containing 10 percent of parathion, with methyl chloride as the propellent gas, has given exceptional control of a number of greenhouse pests, such as aphids, thrips, and greenhouse whitefly, various species of mites, mealybugs, the leaf roller *Platynota stultana* (Wlsm.), and the Surinam roach. Tests on many kinds of plants have given no indication that this aerosol will injure plants when used at this strength to kill insects. Further research is necessary to determine the health hazard to persons exposed to parathion aerosols.

Aerosols containing tetraethyl pyrophosphate have given outstanding results against some greenhouse pests. Ten percent of hexaethyl tetraphosphate (tetraethyl pyrophosphate content 20 percent) was very effective against spider mites, aphids, the greenhouse whitefly, and the Mexican mealybug, but it caused plant injury to some varieties of chrysanthemum, rose, and tomato. An aerosol containing 2.5 percent of technical (40 percent) tetraethyl pyrophosphate was just as toxic to aphids and spider mites, but less effective against the green-

house whitefly. Appropriate safeguards have been outlined for the use of these aerosols, and they are now in commercial use.

Soil Characteristics Affect Reaction of Wireworms to Fumigants

Soil temperatures and certain physical characteristics of the soil were found to affect the efficiency of soil fumigants for the control of wireworms. The performance of ethylene dibromide, 1,1-dichloro-1-nitroethane, and D-D mixture (1,2-dichloropropane and 1,3-dichloropropylene) was compared in laboratory and field experiments in Washington. In moist soil at temperatures from 43° to 77° F. ethylene dibromide was the most effective except at the lowest temperature, where 1,1-dichloro-1-nitroethane was slightly more toxic. The D-D mixture was most efficient at all temperatures in compact soil, but the other two fumigants were more efficient in loose soil. In plot tests 1,1-dichloro-1-nitroethane was superior to the other materials when injected to a depth of 15 inches in the soil.

Field tests with injection machines and plow applicators confirmed the small-scale findings. It was further demonstrated that most of the fumigant is either sorbed by the soil or escapes by diffusion, so that only a small part of the original dosage is left to kill the wireworms. No way to control soil sorption has been found, but diffusion can be reduced by harrowing lightly immediately after applying the fumigant, to produce a thin layer of finely divided soil on the surface, which acts as a seal. The effectiveness of the fumigants is also increased by plowing before application and using some compaction, such as a pressure wheel behind each injection point, to close the furrows.

Several of the new chlorinated hydrocarbon insecticides were also found to be toxic to wireworms when mixed with the soil. Benzene hexachloride is the most efficient and cheapest material yet tested for wireworm control, but its use in the soil has given a bad taste to such root crops as potato, beet, and carrot, and this effect has sometimes been carried over to the next year.

Low-Rotenone Dusts Effective Against Mexican Bean Beetle

Studies in Virginia indicate that the cost of controlling the Mexican bean beetle may be reduced and supplies of the rotenone insecticide conserved by using a piperonyl compound with rotenone dust. In 1947 dusts containing as little as 0.125 percent of rotenone plus 0.5 percent of piperonyl cyclonene or piperonyl butoxide were found to be as effective against the Mexican bean beetle as those containing 0.5 percent or more of rotenone. The addition of piperonyl cyclonene to DDT, its methoxy analog, and sabadilla did not increase the efficiency of these insecticides. Parathion dust and a mixture of the methoxy analog of DDT and sulfur were fairly effective against the bean beetle, but hexaethyl tetraphosphate, chlorinated camphene, and chlordane were inferior to the 0.5-percent-rotenone dust.

New Materials Tested Against Beet Leafhoppers on Beans

In Idaho DDT emulsions were found to cause high mortality of beet leafhoppers on beans grown for seed, and thus to protect them

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from curly-top disease. Some emulsions injured the bean plants, but such injury was avoided by using toluene as the solvent and a phthalic glyceryl alkyd resin as the emulsifier. The effectiveness was not increased when pyrethrum extract, wettable sulfur, or hexaethyl tetraphosphate was added to the DDT emulsion.

Eight applications of a dust containing 10 percent of DDT also gave adequate protection to a field of a susceptible variety of beans exposed to a severe leafhopper infestation. Dusts or sprays containing chlordane, chlorinated camphene, TDE, or hexaethyl tetraphosphate were less effective than those containing DDT.

New Treatments Show Promise for Control of Onion Thrips

Several new treatments showed promise against the onion thrips on table onions. In southern Idaho a DDT-nicotine sulfate emulsion gave best control accompanied by outstanding increases in yield. In California good results were obtained with a DDT dust. Both these preparations were more effective and cheaper than sweetened nicotine sulfate or tartar emetic sprays currently used for this thrips. Benzene hexachloride, chlordane, chlorinated camphene, and a mixture of DDT and hexaethyl tetraphosphate also appeared promising, but the methoxy analog of DDT was less effective.

On onions grown for seed benzene hexachloride dusts were the most effective in reducing infestations, followed in order by DDT, chlorinated camphene, chlordane, and nicotine sulfate. There was no significant difference in yields of onion seed between any of the treatments.

Studies on Pea Insects Continued

DDT was the most effective insecticide tested for the control of the pea aphid and the pea weevil in the Pacific Northwest. Benzene hexachloride, the methoxy analog of DDT, and chlorinated camphene gave promising results against the weevil, but not against the aphid. DDT residues on peas constitute a health hazard where the vines are fed to livestock, and benzene hexachloride gives an objectionable flavor to peas for table use.

Some types of aircraft were found to be satisfactory for applying sprays to control pea insects, but ground machines gave better results with dusts.

Alfalfa was shown to be a source of aphid infestations in pea fields nearby.

Plants Differ in Tolerance to Organic Insecticides

That plants differ in their tolerance to the new organic insecticides has become increasingly evident as investigations with these materials for the control of insects have progressed. Certain plants are injured, whereas other plants, or even other varieties of the same plant, are not affected. In tests on bush lima beans at Beltsville, Md., in cooperation with the Bureau of Plant Industry, Soils, and Agricultural Engineering, sprays containing a DDT wettable powder caused a pronounced stunting and reduction in yield in one variety, Triumph (U. S. 343), but not in 13 other varieties. In other tests at Beltsville some varieties of tomato, chrysanthemum, and rose were

injured by aerosols containing 10 percent of hexaethyl tetraphosphate (2 percent of tetraethyl pyrophosphate), but only during the season of short daylight. Kalanchoe is the only common ornamental plant that is severely injured by DDT in aerosols or sprays, but other organic insecticides except chlordane are not injurious to this plant.

Control of Aphids on Tobacco Sought

An unprecedented outbreak of aphids occurred on tobacco during 1946, 1947, and early in 1948. In preliminary tests to combat these aphids, dusts or sprays containing parathion or tetraethyl pyrophosphate were effective. Benzene hexachloride dusts and sprays and nicotine sprays were less effective. The health hazard incurred by the use of parathion or tetraethyl pyrophosphate and their effect on the quality of tobacco have not yet been determined. Benzene hexachloride gave an undesirable odor and flavor to the tobacco. The cost of nicotine sprays is too high for practical use. Further search is being made for a suitable method of control.

New Pest of Crucifers Found in Alabama

In March 1947 an insect new to the United States and now known as the yellow-margined leaf beetle (*Microtheca ochroloma* Stål) was discovered feeding on young cabbage in Mobile County, Ala. This insect is reported to be a serious pest of crucifers in Argentina and Uruguay. A preliminary survey in April 1947 disclosed that this leaf beetle was well distributed in the southern part of Mobile County. Larvae and adults were found feeding on radish, turnip, mustard, and collards, as well as cabbage. Quarantine inspectors of this Bureau, in cooperation with State workers, then made a broader survey to ascertain whether the insect occurred in the Southern States and in New York and California. Negative results were obtained in all States except Alabama, where infestations were found in Mobile and Baldwin Counties, all in the southern part of that State. Late in April 1948 this leaf beetle was found by Federal workers to be well established over at least the southern half of Mobile County and to be causing serious damage to turnip and mustard.

Campaign Against Sweetpotato Weevils Intensified

South-central Louisiana is the heart of commercial sweetpotato production. The crop greatly increased there during the war, as also did sweetpotato weevil infestations. With Federal and State funds a comprehensive program is well under way to reduce economic damage with the hope of eradication later. Sweetpotatoes are inspected at harvest-time. Infested potatoes are culled out, and the others placed in storage. Lightly infested potatoes are fed to livestock or sent to livestock-feed dehydrating plants, and those badly infested are destroyed. Fields are plowed in winter, and remnant potatoes and roots are picked up by hogs and cattle. At shipping time the sweetpotatoes are again culled for weevils under the supervision of inspectors. After shipping is completed, the warehouses are cleaned of refuse and sprayed with DDT. Seed potatoes are saved from noninfested fields or secured from weevil-free parts of the State, or certified plants are purchased. Potato rem-

nants and trash around grading and packing sheds are destroyed. These sanitation measures saved hundreds of thousands of bushels of the 1947 crop that would otherwise have been discarded.

Vigorous measures are being applied to eradicate weevils in important areas of Florida, Georgia, South Carolina, and Texas. In these areas planting of sweetpotatoes is being prohibited under State authority, in order to eliminate host material for one or more years and thereby starve out the weevils. Growers recognize this as a sound procedure. It is particularly worthwhile in the valuable sweetpotato-growing area around Tifton, Ga.; in the recently discovered infested area in Jefferson County, Fla., to protect the area that is being cleaned up in Georgia; in the only infested county, Charleston, in South Carolina; and in Angelina, Nacogdoches, and San Augustine Counties in Texas to eradicate the residual infestations.

Surveys are being continued in and around infested areas and at points exposed to infestation through contraband shipments of potatoes or plants. States are being assisted in enforcing their quarantines to prevent movement of materials liable to carry the pest to other potato-growing areas.

Studies on methyl bromide fumigation showed that the recommended dosage was tolerated by sweetpotatoes that were well cured, but that those already injured by cold were further damaged by the fumigant.

JAPANESE BEETLES

Grubs in Turf Quickly Killed With Chlordane

Chlordane was found to be as effective as DDT and faster in controlling Japanese beetle grubs in turf. The experiments indicated that less than half as much chlordane per acre is required and that this material is effective under a wider range of conditions than is DDT. Chlordane not only killed the brood of grubs present at the time of application in the spring of 1947, but it retained sufficient residual toxicity to eliminate most of the subsequent brood by mid-September. How much longer it will be effective remains to be determined. Chlordane appeared to be equally effective as a dust or a spray. At dosages up to 25 pounds per acre it had no effect on the color, general appearance, or growth of several different grasses or clover.

Quarantine and Control Activities

The Japanese beetle quarantine was revised, effective April 30, 1948, to omit the boundaries of the heavily infested area and to provide for the issuance of administrative instructions to designate such boundaries on the basis of seasonal conditions. The regulated areas in Maryland, New York, and Virginia were slightly extended. The entire regulated area now covers nearly 130,000 square miles in 13 States and the District of Columbia.

A new method of treating refrigerator carloads of bagged white potatoes and sacked onions, devised by the Bureau, was approved. A twin-nozzle applicator is used to propel the DDT dust above and through the load simultaneously. Cars dusted in this way do not need to be treated before they are loaded.

To detect Japanese beetle infestations outside the regulated area in

1947, scouting and trapping, largely in cooperation with State agencies, were conducted in 38 States, including all nonquarantined States except Arkansas and Nevada. More than 1,000 sites were scouted—plant-growing establishments, airports, freight terminals, and other areas suspected of being infested. At many locations scouting for Japanese beetles and white-fringed beetles was combined. No important infestations were found remote from known infested areas. Single beetles were found for the first time at 8 points in 5 States. At 30 sites the number of beetles caught warranted quarantine action or soil treatments. During May and June 1948 about 13,000 traps were placed at 124 locations in 20 States; 37 of the locations were airports. The collections up to July 1 did not indicate any significant spread of the beetle.

To control Japanese beetles outside the quarantined area, DDT or lead arsenate was applied to 587 acres at 27 locations in 9 States to kill grubs in the soil, and DDT was applied to foliage at 38 locations in 10 States to kill adult beetles. These treatments were made, in cooperation with State agencies, instead of placing the areas under quarantine. More and better equipment for treating foliage with insecticides is available for use in 1948.

Special efforts were made in 1947 to prevent the spread of Japanese beetles by airplanes flying from the infested area. Inspectors at 5 airports in the Atlantic Coast States checked the loading of 7,000 planes, and removed 2,800 beetles from passengers and baggage. Supervision was given to the treatment of 6,300 commercial planes and 4,600 military planes with DDT aerosols. Six air lines operating from La Guardia Field cooperated in making residual applications of DDT to the interior surfaces of 180 planes. Similar treatments were made in June 1948.

To reduce still further the chances of Japanese beetles being transported in airplanes, cars, and other carriers in 1947, DDT was applied to host plants and environs at 6 airfields and 15 farm-produce loading sites where beetles were numerous. Extensive plant-growing areas in Lake County, Ohio, and near Newark, N. Y., were treated with DDT by airplane. Mist blowers were used to apply DDT to roadside areas in Virginia. Such control treatments under State and Federal auspices increase the effectiveness and lower the cost of quarantine enforcement.

Restrictions on the movement of farm produce and cut flowers from the heavily infested area were in effect throughout the summer of 1947. During this period 3,400 carloads and 800 truckloads of white potatoes were dusted with DDT. An additional 200 carloads and a few truckloads of potatoes, as well as 70 carloads and 200 truckloads of miscellaneous farm produce, were fumigated with methyl bromide. About 1,200 carloads and 1,400 truckloads were certified after visual inspection, as were also 8,900 packages of cut flowers. Inspection activities were carried on at 48 locations in 1947, almost three times as many as in 1946. There was an increase of 500 carloads and an eightfold increase in truckloads of farm products certified over the previous year. In 1948 more than 1,200 carloads of potatoes were treated for certification.

Eight highway-inspection stations, seven in Virginia and one at the western end of the Pennsylvania Turnpike, were in operation during

the summer of 1947. During this period 120,000 trucks passed these stations.

Inspectors stationed at about 30 points in the regulated area certified nearly 72,000,000 nursery and greenhouse plants for movement to nonregulated areas and 10,000,000 plants for movement within the regulated area. To provide these services quarantine inspectors made nearly 25,000 calls to growers, shippers, and homes. To qualify plants for certification without inspection, growers treated 4,000,000 square feet of growing area, 2,300 cubic yards of potting soil, and nearly 4,000,000 plants with approved insecticides. Growers are accepting such treatments as the most satisfactory way of meeting quarantine requirements, and some report an improvement of treated over untreated stock.

WHITE-FRINGED BEETLES

New Treatments Aid Control of Beetles

With the development of new methods and equipment for applying DDT great advances have been made in combating the white-fringed beetle.

To control beetle populations that threaten long-distance and important local spread, the Bureau applies DDT to foliage every 2 weeks, using ½ to 1 pound per acre. For treating infested agricultural lands, the Bureau applies DDT to the soil at the rate of 10 pounds per acre, which the farmer cultivates into the top 3 inches. The States furnish the material for the soil treatments. The residual effect of the DDT will control beetle larvae in the soil for at least 4 years.

Jeep-mounted concentrated-spray machines and high-velocity dust and spray blowers are important innovations which permit treatment of land more rapidly and effectively at a lower cost. During the year 20,570 acres were treated with DDT, 12,057 acres by airplane. The 10-pound soil treatment was given to 1,242 acres.

During the year State and Federal quarantines were revised to include newly found infested areas. Additional treatments were authorized as a basis for certification of material for movement to nonregulated areas. These treatments include incorporation of DDT into soil of nurseries at the rate of 50 pounds per acre supplemented by foliage sprays every summer at ½ to 1 pound per acre.

In studies on new insecticides against the white-fringed beetle, technical benzene hexachloride also gave complete kill of the larvae when applied as a soil treatment at 3 pounds of the gamma isomer per acre. Further tests with this material must be made, however, before its use can be recommended or approved.

Present Status of Beetle Infestations

Since 1936, when the white-fringed beetle was discovered on cotton, corn, and other crops in western Florida, surveys have been conducted to locate other infestations, to delimit the areas of known infestations, and to determine whether there has been any spread to outlying and distant points. This beetle is now known to be present in Alabama, Florida, Georgia, Louisiana, Mississippi, North Carolina, and South Carolina—on approximately 215,000 acres in 114 counties. Surveys

in 21 other States and the District of Columbia, as far north as New York and Minnesota and as far west as Texas and Oklahoma, have given negative results. Control and regulatory measures promptly undertaken have materially retarded spread of the pest, although it has established itself in some additional areas.

FOREST INSECTS

Tussock Moth Outbreak in Northwest Controlled With Aerial Sprays

Airplane spraying with DDT of more than 400,000 acres of forest near Moscow, Idaho, in the summer of 1947 brought under control the severe outbreak of the Douglas-fir tussock moth that had defoliated the stands in 1946 and had already killed the timber on about 16,000 acres. This work, which was discussed more fully in last year's report, was undertaken in cooperation with the Forest Service, the States concerned, and private timber owners. It is estimated that 1,518,856,000 board-feet of timber, valued at $84,328,000, would have been killed if nothing had been done to prevent defoliation in 1948. Surveys conducted in the fall of 1947 indicated that the control program had been so successful that no further spraying should be necessary. This conclusion has been borne out by the absence of active infestations in 1948.

Aerial Surveys Advance Forest-Insect Detection

An aerial-reconnaissance survey of 7,750,000 timbered acres in the Blue Mountains of Oregon and Washington was completed in 1947 at a cost far below that required for earlier ground surveys. About 710,000 acres of spruce budworm infestation, 70,000 acres of Douglas-fir tussock moth infestation, and several small outbreaks of other species were mapped, and the general status of the western pine beetle was recorded. All this was done in about 30 hours of flying time—less than 2 weeks' work for obtaining information that would have taken a ground crew most of the summer to acquire. Clearly, aerial surveys are a marked step forward in the field of forest-insect detection. Many details and procedures must still be worked out, however, before the method can be used for obtaining more than a general idea of infestation boundaries and general estimates of timber losses.

New Equipment Aids Control of Forest Insects

Labor costs are now so high that artificial control of bark beetles in forest stands has been almost prohibitively expensive where thousands of trees must be treated. Entomologists working with forest engineers have assembled portable power sprayers for use in applying fuel oil or penetrating lethal sprays to trees infested with bark beetles. Some of this equipment is mounted on jeeps or weapon carriers. During the early part of the season, when it is safe to use fire, fuel oil is applied to the trunks of trees so that they can be ignited and heated to a temperature that kills the insects beneath the bark. The use of fire is usually hazardous, however, and consequently most of the infested trees are treated with orthodichlorobenzene in fuel oil (1:6), which penetrates the bark and kills the insects.

The new types of sprayers were used in 1948 on several very large projects for control of the Black Hills beetle and the mountain pine beetle in South Dakota, Wyoming, and Idaho. They proved vastly superior to hand sprayers used in former years. Treatment costs were reduced despite higher hourly rates for labor, because the work could be done more rapidly. With this new equipment it was possible to do a very complete and satisfactory control job, even though more trees were found to be infested than had been expected on the basis of preliminary surveys.

At Beltsville, Md., work was continued on the development of aerial spraying for the control of destructive forest pests. Various new atomizing devices were tested on trainer-type biplanes, but none were superior to the hollow-cone nozzles. With these planes the characteristics of the spray deposit were found to be affected by the spacing of the nozzles, the direction of the nozzle orifices relative to the flight path, and the spray viscosity and volatility. In general, the most uniform and effective deposits were obtained by spacing the nozzles slightly closer near the wing tips, placing the orifices so that the spray was directed to the rear, and applying a spray of medium viscosity and volatility. Preliminary steps were taken to study the possibility of improving the spray pattern by varying the positions of outlets in the air stream around the plane.

Outbreaks of Mountain Pine Beetle and Black Hills Beetle in Rocky Mountains

An aggressive outbreak of the mountain pine beetle has been in progress for several years in the northern Rocky Mountains region. Deficiency funds were made available to the Forest Service and the National Park Service for treating over 100,000 infested lodgepole pine trees on the Targhee and Teton National Forests and in Teton National Park in 1948. The work was done under the technical direction of this Bureau.

A smaller but potentially dangerous infestation of lodgepole pine stands by the mountain pine beetle was uncovered by the 1947 surveys on the Kootenai National Forest in northern Idaho. It is estimated that about 4,600 trees on 1,260 acres are infested. Control is being attempted in 1948. This beetle also continues to infest nearly every mature stand of western white pine in the northern Rocky Mountain region. On four units of the Coeur d'Alene National Forest in northern Idaho, totaling 15,240 acres, it was estimated that there were 4,000 infested trees in the fall of 1947. This condition has persisted for several years and much valuable timber has been destroyed.

About 44,000 ponderosa pine trees infested with the Black Hills beetle were found on the Black Hills and Harney National Forests and in Custer State Park in South Dakota and Wyoming in 1947, as compared with 6,300 infested trees in 1946. Deficiency funds were provided for control operations in 1948 by the Federal Forest Service and South Dakota State Forest Service, under technical direction of this Bureau.

Ips Beetles Increase Near Sawmills in California

The tremendous increase in sawmills in California, from 290 before the war to 1,120 in 1947, has greatly aggravated damage by *Ips* beetles

in pine stands adjacent to the slashings left by these mills. All along the lower slopes of the Sierra Nevadas and in southern California thousands of pines have been killed by *Ips* beetles, which breed in untreated slash. In certain areas of southern California more trees were killed by beetles than were cut by the sawmills that created the beetle-breeding slash. Lack of experience in handling this problem has made it necessary to give special attention to this critical situation.

Aerial Sprays Kill Insects on Pine Plantations

Several hundred acres of ponderosa pine plantations in California were sprayed with DDT in fuel oil for control of *Cylindrocopturus eatoni* Buch., known as the pine reproduction weevil. Technical supervision was given in the aerial spraying of 3,770 acres of red and jack pine plantations in Wisconsin and Michigan to control the Saratoga spittlebug. More than 12,000 acres were also sprayed by plane to control the red-headed pine sawfly on plantations of red, jack, and shortleaf pine in Wisconsin, Michigan, and Illinois.

Airplane applications of DDT in September 1947 gave encouraging results against the white-pine weevil. This is one of the most destructive forest insects in the Northeast, and a cheap practical control is greatly needed. More than 90 percent mortality of the adult weevils was obtained with 3 pounds of DDT in 3 gallons of spray per acre applied by covering the area twice. This dosage is heavier than is desirable for use over large areas, and it is hoped that by further improvements in methods of application the dosage can be reduced. Laboratory tests indicate that benzene hexachloride gives quicker knock-down of weevils than DDT, and airplane applications with this new insecticide are planned for 1948.

Egg Parasite of Pine Sawfly Reduces Need for Spraying

A hymenopterous parasite, *Closterocerus cinctipennis* Ashm., destroyed over 95 percent of the eggs of the red-headed pine sawfly in several heavily infested plantations in southern Illinois, so that it was unnecessary to spray these areas. Careful examination was required to determine which plantations could safely be omitted from the spraying program.

Spruce Budworm Control Promising

The 1947 surveys showed that the spruce budworm infestation in the Adirondack section of New York had greatly subsided since 1946. Populations increased slightly in Vermont but not in New Hampshire. There was considerable increase in Maine, collections being reported from 146 towns compared with 49 in 1946. The outbreak is reported to be increasing in Quebec and western New Brunswick. This may eventually have a marked effect on developments in Maine.

The spruce budworm situation in Canada and the United States in 1947 is indicated in figure 1.

Experiments in airplane spraying with oil solutions of DDT to control the spruce budworm were conducted in cooperation with the New York State Conservation Department. Twelve plots, totaling about 2,000 acres and ranging in size from 42 to 314 acres, were treated.

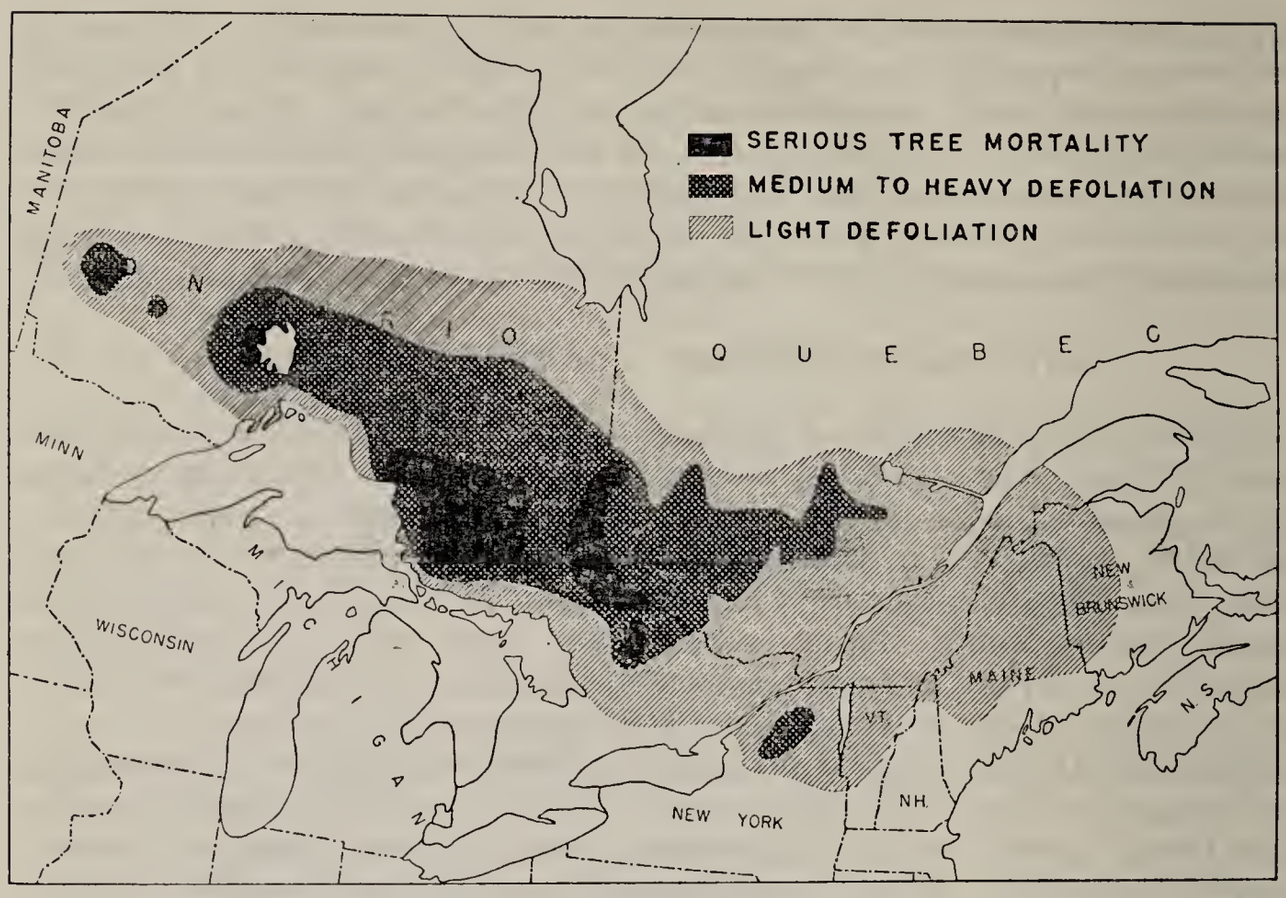

FIGURE 1.—Areas in Canada and the United States infested with the spruce budworm in 1947.

Within the limits of the experiments, the effectiveness of the treatment increased with the amount of DDT and the gallonage per acre. More even distribution of the spray was obtained when an area was flown over at least twice. One covering with 1 pound of DDT in ½ gallon per acre caused little or no larval mortality, but 2 pounds in 3 gallons per acre applied by flying over the area three times gave practically complete control. More study is needed to determine whether the better distribution resulting from repeated applications or an increase in dosage is more important in obtaining a good kill. The concealed feeding of the budworm makes it difficult to reach; yet laboratory tests show it to be very susceptible to DDT.

In preliminary tests other new insecticides, such as chlorinated camphene, benzene hexachloride, chlordane, and hexaethyl tetraphosphate, applied from the ground with a mist blower, were toxic to the spruce budworm but not so effective as DDT.

Parasites were responsible for much of the sharp reduction in spruce budworm populations in the Adirondack area of New York. Studies on sample plots showed that mortalities due to parasites ranged from 64 to 86 percent in 1947, and from 49 to 81 percent in 1946. The aggregate mortality, including that caused by birds, diseases, starvation, and unfavorable weather conditions in addition to parasites, must have been nearly 99 percent; otherwise there would have been an increase instead of a decrease in the budworm population.

Gypsy and Brown-Tail Moths

Moth Populations Lowest in Several Years

Except in parts of southeastern Massachusetts, gypsy moth populations were the lowest in several years. During the summer of 1947 only

7,422 acres of woodland showed more than 25 percent defoliation. This is the smallest acreage defoliated by the gypsy moth since 1924. Manual surveys on about 2,160,000 acres showed no further spread beyond the periphery of the suppressive area in western New England and eastern New York or in the isolated infestation of Pennsylvania, and no infestation was found in New Jersey, where an outbreak of gypsy moth was eradicated several years ago.

DDT sprays and parasites were partly responsible for this reduction in infestation. Wilt disease and abnormally early hatching in the spring of 1947, followed by a long rainy, cold spell, added to the decrease. During the summers of 1945 and 1946 many caterpillars died from starvation after heavy defoliation of much of the tree growth on over 800,000 acres and 600,000 acres, respectively.

The winter of 1947–48 was unusually cold in the gypsy moth-infested areas. Temperatures were as low as −30° F. in many sections, causing heavy mortality of eggs in clusters not protected by snow. Only about 60 percent of the eggs hatched in the spring, and hatching was approximately 1 week later than normal. Egg clusters were collected from numerous locations in New England, eastern New York, and Pennsylvania.

The brown-tail moth infestation also is at a very low ebb and is present only at scattered locations in towns along the Atlantic coast from Provincetown, Mass., to Brunswick, Maine, with no known infestations beyond New England. The insect is not known to be present in Vermont, Connecticut, or Rhode Island.

DDT Applied to 265,000 Acres

Spraying for gypsy moth control was materially increased in the spring of 1948. In general oil solutions of DDT were used at the same rates as in the preceding year—1 pound of DDT in 1 gallon in applications prior to hatching and ½ pound of DDT in 1 gallon after the eggs had hatched. Two twin-engine C–47 planes were acquired on a lease basis from the War Assets Administration, and one was equipped with insecticide tanks, pump, and spray booms. Four small biplanes and six mist blowers for ground applications were also made ready for the 1948 spray season. In addition, the New York State Conservation Department used two airplanes and two mist blowers, and the Pennsylvania Department of Agriculture furnished one blower. The State agencies also supplied most of the insecticides and much of the labor.

Some of the small planes sprayed considerably more than 1,000 acres on good spraying days, and one of them treated 2,200 acres in a single day. The C–47, which carried an average of 825 gallons of insecticide on each trip, sprayed about 6,000 acres on each of several days, and throughout the season averaged 1,638 acres per hour of actual flight time. This plane treated a total of 77,690 acres in Pennsylvania and 4,540 acres in New York.

The total area treated by aircraft was 135,385 acres in Pennsylvania and 76,475 acres in New York and New England. Ground mist blowers were used to treat 33,315 acres in Pennsylvania and 20,155 acres in New York and New England. A small amount of spraying was done with knapsack sprayers. A total of 265,445 acres were sprayed with DDT in the Federal-State cooperative program. In spite of the rainy season the planned objectives were reached, and preliminary examinations at the sites of the heaviest infestations that were sprayed have failed to show any surviving gypsy moth larvae.

Sex Attractant Collected for Use in Surveys

To obtain sex-attractant material for use in gypsy moth surveys, 1,336,680 female pupae were collected and processed in 1947, the largest number ever obtained for this purpose. Owing to improvements in handling, the percentage of adults issuing from this material was increased and their mortality prior to the clipping of the abdominal tips was reduced. Sufficient material was obtained to provide 100,000 tips for research purposes, to supply a liberal amount of attractant for the 1948 survey, and to leave a reserve in case less material should be available in the next year or two.

More than 5,736,000 acres in New England, New York, Pennsylvania, and New Jersey were surveyed with the aid of 13,903 sex-attractant traps dispersed throughout 282 townships. Over much of this area the traps were set out in a gridiron pattern to obtain better coverage. Therefore, about 2,000 more traps were used than the year before, although the area surveyed was slightly smaller. The only catch in areas that had been sprayed with DDT in previous years was a single male taken near a known infestation in adjacent untreated woodland. A total of 100 male gypsy moths were taken in 63 traps exposed in untreated portions of 28 infested townships within or bordering the area considered to be generally infested.

Activities Connected with Quarantine Enforcement

In the area in New England and New York which is regulated by the gypsy and brown-tail moths quarantine, Federal inspectors at 24 locations were on call from growers, producers, and shippers to carry out various phases of quarantine enforcement with assistance of State inspectors.

Application of DDT at tourists' camps, junk yards, sawmills, quarries, and nurseries was again tested as a means of eliminating the moths and thus making regulated articles eligible for certification without inspection or specific treatment. Mist blowers, knapsack sprayers, and autogiros were used to distribute the DDT. Tree wardens and State agencies, as well as plant growers and owners of these sites, participated in the tests. Continued good results may lead to much wider use of this more efficient approach to quarantine enforcement.

During the year 295 tourist and camp sites, 160 junk yards, and 13 gas-cylinder establishments were scouted for moths. Infestations were found in 88 tourist camps and 29 junk yards, and control measures were applied by the owners or operators.

More than 400 lumber and pulpwood producers and quarry operators in areas where no moths are found by scouting ship regulated articles on the basis of formal agreements with the Bureau. The operators obtain certificates in advance upon agreement to handle and ship certified articles in a safe manner. Similar agreements are made with processors. About 37 percent of the lumber and 83 percent of the quarry products moved under quarantine in 1948 were certified on this basis.

More than 230,000,000 board-feet of lumber, as well as large quantities of pulpwood and other wood products, were permitted to move from the quarantined area during the year. Certificates were also issued for the movement of forest products to Canada in compliance with that country's quarantine on such products.

The number of Christmas greens certified for shipment during the 1947 season totaled more than 320,000 trees, 100,000 boxes of boughs and wreaths, and 47,000 lots of mixed evergreens. More than three-fourths of the trees were fumigated with methyl bromide, but nearly all the other greens were certified on the basis of visual inspection. In the fumigation work 1,450 pounds of methyl bromide were applied by Federal, State, and private fumigators at 38 locations. In the course of inspection egg clusters were removed from shipments to California, Ohio, Texas, and Virginia.

Inspectors also certified the movement of more than 360,000 tons of stone and quarry products and over 400,000 monumental pieces and specimen stones.

Since about two-thirds of the area under regulation because of the gypsy and brown-tail moths is also quarantined because of the Japanese beetle, nursery stock and field-collected plants from this section are inspected and certified as to freedom from both pests at the same time. In 1948 nearly 12,000,000 plants and 3,000 bundles of seeds and cuttings were certified as free of gypsy and brown-tail moths.

Effects of DDT on Fish and Fish-Food Organisms

The effect of aerial applications of DDT on fish and fish-food organisms was studied in cooperation with the Fish and Wildlife Service. One-mile sections of bass and trout streams were sprayed with DDT dissolved in oil or as a water suspension at the rate of 1 pound of DDT per acre, an amount that is adequate to control many forest insects.

The oil spray destroyed a maximum of about 90 percent of the fish-food organisms, as compared with 70 percent loss from the suspension. Stream insects rapidly reestablished themselves, however, and within a year the number of fish-food organisms was as great as before the treatment. In some streams the insect-species composition had changed.

There was no appreciable damage to fish, turtles, or frogs. Fish were also more susceptible to the oil solution than to the suspension. Small fish were more affected than larger ones. Trout were more resistant than several species of warm-water fish.

On large control operations there has been little damage to fish and other vertebrates where the DDT has been properly applied at the rate of 1 pound per acre. At this dosage DDT has no measurable effect on birds or mammals.

Protection of Wood Products Against Termites and Other Pests

Wooden crates and other materials in Army supply dumps may be protected from subterranean termites with insecticides applied to the surface of the soil. A water solution containing 10 percent of sodium arsenite or an oil solution containing 5 percent of DDT, applied at one-half pint per square foot, will be effective for more than a year. These results were obtained from tests conducted in Mississippi and Panama in cooperation with the Army Corps of Engineers.

The Bureau is now represented on the joint Army and Navy panel which is to coordinate all research on the control of marine borers under the auspices of the National Research Council.

Benzene hexachloride continued to give promising results for control of ambrosia beetles attacking logs and lumber. In tests in Mississippi and Louisiana, including large-scale tests at mill sites, an oil solution containing 0.48 percent of the gamma isomer gave about 75 percent protection against these beetles for 3 or 4 months during the time of their greatest activity. An aqueous suspension of wettable benzene hexachloride containing 0.2 percent of the gamma isomer was found to protect green lumber during its seasoning period. Benzene hexachloride has been found to be compatible in all respects with the stain preventives used by lumber producers. It is the first insecticide that has offered any protection against these beetles, which cause heavy losses to the lumber industry each year.

PESTS AND DISEASE CARRIERS AFFECTING MAN

Much of the research on insect pests and disease carriers attacking man continues to be carried out under funds transferred from the Department of National Defense. Its primary purpose is to develop insecticides and repellents for military use, but much information obtained from such studies has already been adapted to benefit civilians in all parts of the globe. The headquarters for this research program is Orlando, Fla.

Insects in Arctic Areas Studied

Special investigations on insects in Alaska and Canada have been undertaken during the year in cooperation with our Army and Navy and the Canadian Department of National Defense.

In Alaska 18 species of mosquitoes, 20 species of black flies (Simuliidae), and 8 of punkies (*Culicoides*) have been collected in connection with species surveys and ecological studies. Some species of the last two groups may be undescribed. A number of species of mosquitoes and black flies have also been taken near Churchill, Manitoba.

At Churchill it has been demonstrated that the application of insecticides to ice and snow will prevent mosquito breeding when the ice and snow melt. DDT, chlordane, chlorinated camphene, and benzene hexachloride were tested in various formulations. All were found to be effective when used in this way, but DDT was the best. Both wettable powders and emulsions applied at the rate of 0.1 pound of DDT per acre destroyed all larvae when the ice melted several weeks later. The oil solution was effective at 0.25 pound of DDT per acre.

DDT was also found to control black flies breeding in streams. As little as 0.4 part per million maintained for 15 minutes destroyed the larvae without apparent harm to fish. Larvae a mile or more down stream from the point of application were killed.

Of a large number of new insect repellents tested against mosquitoes and black flies in Canada, several were equal to or more effective than the standard military repellents. The most promising were the x-propyl ester of N,N-diethylsuccinamic acid, 5-ethyl-5-nitro-2-propyl *m*-dioxane, the ethyl ester of beta-phenyl hydracrylic acid, the dimethyl ester of bicyclo-(2,2,1)-5-heptene-dicarboxylic acid, and the 2-phenylethyl ester of hydracrylic acid.

In efforts to control mosquitoes, black flies, and punkies by measures to kill the adults, it was found that the treatment of areas of about a

square mile provided only temporary control. Insects from surrounding untreated areas invaded the territory within a short time.

New Insecticides Compared With DDT for Mosquitoes and Black Flies

The outstanding new insecticide tested during the year for the control of both adult and larval mosquitoes was parathion. It was found to be 2 to 3 times as effective as DDT against adult yellow-fever mosquitoes and 10 times as toxic to larvae of the common malaria mosquito. In field tests more than 90 percent control of anopheline larvae has been obtained with 1 pound of parathion applied to 100 acres of water surface. Further work on its toxicology is necessary, however, before this material can be recommended for use.

DDT applications to snow in mosquito-breeding areas of the Northwestern States gave results comparable with those obtained in similar tests in Canada. From 1 to 3 pounds per acre applied in the fall prevented larvae from developing the following spring, and water taken from treated areas in the summer and early fall was toxic to larvae.

In tests in Florida with DDT as a prehatching larvicide for saltmarsh mosquitoes, 1 to 2 pounds per acre has been found to prevent breeding for most of the season.

In laboratory tests TDE was as effective as DDT against two species of *Aedes*. The other chlorinated hydrocarbon insecticides were also toxic to mosquito larvae but generally less so than DDT.

Several repellent materials have been found which when applied to clothing will prevent mosquitoes from biting through for as long as 60 days. Among the most promising are N-cyclohexyl-beta-butoxyethoxyacetamide, 3-(2-ethylhexyloxy)-1,2-propanediol, beta-naphthol, and tetrachlorophenol.

In New Hampshire TDE was found to be superior to DDT as a black fly larvicide, and less toxic to trout. It was effective when applied to streams at a rate which maintained a concentration of 0.2 part per million for 10 minutes. Good control was obtained in a 5-mile section of a stream when applications were made at intervals of 1 mile.

New Materials Protect Against Wood Ticks, Chiggers, and Fleas

Chlordane and chlorinated camphene are slightly more effective than DDT against the lone star tick and the American dog tick in woodlands. More than 90 percent control has been obtained for 3 to 4 weeks after dusts or emulsion sprays have been applied at the rate of about 2 pounds of the insecticide per acre. These materials control chigger mites for several weeks when applied at the rate of 2 to 4 pounds per acre. They are also effective against fleas.

Several thousand chemicals have been tested as clothing treatments to protect individuals from these pests. The most promising against ticks are *n*-butyl mesityl oxide oxalate (Indalone), N-butyl acetanilide, 2-ethylhexyl diethylene glycol monoether, and *n*-hexyl mandelate. The following compounds gave at least nearly complete protection against chiggers after clothing impregnated with them had been laundered seven times: Benzil, 2-thenyl benzoate, *p*-cresyl benzoate, diphenyl carbonate, and 2-thenyl salicylate. Benzil and diphenyl

carbonate were also effective for several days when applied to the clothing as 5-percent dusts.

In laboratory tests the best clothing treatments for protection against fleas were the N-(*n*-amyl)amide of 1,2-dicarboxy-3,6-endomethylene-4-celohexane and tributyl phosphate.

Clear Lake Gnat Controlled With TDE

The Clear Lake gnat was eliminated from a lake of about 70 acres in California 3 months after it had been treated with TDE. The experiment was conducted on Blue Lake in Lake County, in cooperation with the California Fish and Game Department. The TDE was applied as an emulsion at the rate of 1 part to 45,000,000 parts of water. In addition to the gnats, larvae of Chironomidae and certain other Diptera were eliminated. The fish population apparently was not seriously affected, although a complete report has not yet been received from the California agency. If their study shows that fish and fish foods are not destroyed by this treatment, it may be both feasible and practical for controlling the gnat in Clear Lake, which is the principal source of the pest.

Chlordane for Control of Ants and Roaches in Houses

Chlordane has given excellent control of the thief ant and the little black ant in houses. A single application was found to be effective for 3 months. In comparable tests DDT did not give satisfactory control of the little black ant.

In tests against cockroaches chlordane has continued to be more effective than DDT. This insecticide is now recommended for use against these pests, with the usual precautions for handling poisons.

PESTS OF FARM AND RANCH ANIMALS

Chlorinated Hydrocarbons Control Many Livestock Pests

The new chlorinated hydrocarbon insecticides—DDT, chlordane, chlorinated camphene, TDE, the methoxy analog of DDT, and benzene hexachloride—have been tested extensively against various insect pests of farm and ranch animals. These materials have generally been used in wettable-powder sprays or dips, but xylene emulsions were also tested.

Horn Flies

Chlorinated camphene and DDT sprays were about equally effective against horn flies in tests in Texas, Kansas, and Missouri. The studies in Kansas and Missouri were conducted in cooperation with the State colleges and experiment stations and the National Livestock Loss Prevention Board. In Texas and Kansas a single application of a 0.5-percent spray, about 2 quarts to an animal, kept them free from horn flies for about a month. Chlordane, TDE, and the methoxy analog of DDT gave protection for about 25 days. In Missouri all these materials were effective much longer. However, the herds under test were less exposed to reinfestation because other cattle nearby were treated by their owners.

Ticks on Cattle

In tests in Texas against the winter tick, sprays containing 0.5 to 0.75 percent of chlordane or chlorinated camphene destroyed most of the engorged ticks present at the time of treatment and prevented infestations for about 8 weeks. DDT and TDE were less effective, especially against engorged ticks, but they protected animals from reinfestation for about 4 weeks.

For protecting cattle from the lone star tick, DDT, chlorinated camphene, and chlordane were about equally effective. However, DDT was less efficient in killing engorged ticks. Wettable powders and emulsions provided fair control for about 2 weeks when applied as sprays containing 0.75 percent of the insecticide.

Benzene hexachloride (technical) was the best material for destroying both species of cattle ticks, but it did not give such long-lasting protection. It destroyed all stages in sprays containing as little as 0.025 percent of the gamma isomer. A combination of benzene hexachloride with other insecticides might therefore provide an excellent treatment for these ticks.

Sheep Ticks

In Oregon and Texas the chlorinated hydrocarbon insecticides were tested as dips and sprays against sheep ticks. All of them maintained complete control for 4 months when used as dips in 0.2-percent concentration, but DDT, TDE, and the methoxy analog of DDT did not provide satisfactory control on sheep in heavy fleece when used as sprays at this strength. Dips containing only 0.05 percent of chlordane, chlorinated camphene, or benzene hexachloride (gamma isomer 10 to 12 percent) gave complete control for 42 days, and in limited tests chlordane and benzene hexachloride were effective as sprays at this concentration.

In general chlordane appears to be the most effective of the chlorinated hydrocarbons against sheep ticks. These materials are more expensive than rotenone, however, which in comparative tests gave excellent control in dips containing the recommended 8 ounces of derris (rotenone 5 percent) per 100 gallons.

Lice

In Texas cattle lice were killed with sprays containing chlordane, chlorinated camphene, TDE, the methoxy analog of DDT, and benzene hexachloride (gamma isomer 10 to 12 percent). A single thorough treatment with 0.5 percent of each material gave complete to nearly complete control of both the short-nosed and the long-nosed louse. Good, but not complete, control of the motile forms of the short-nosed cattle louse was obtained with emulsions containing 0.005 percent of pyrethrins plus 0.05 percent of piperonyl butoxide.

In preliminary tests most of the chlorinated hydrocarbon insecticides also gave complete control of the tail louse (*Haematopinus quadripertusus* Fahrenholz) when used in 1-percent sprays. No tests with benzene hexachloride were conducted.

In limited tests all the chlorinated hydrocarbons gave good control of the hog louse at 0.2-percent concentration. Chlordane and chlorinated camphene appeared to give complete control at this strength.

Biting lice of goats were eliminated completely from test animals

with dips containing 0.2 percent of DDT, benzene hexachloride (gamma isomer 10 to 12 percent), chlorinated camphene, or chlordane.

Cattle Grubs

Chlordane, benzene hexachloride, and chlorinated camphene were not effective against cattle grubs in the backs of animals when applied at strengths up to 2 percent.

Horse Flies and Deer Flies

Limited tests in Texas, Florida, and Georgia indicate that benzene hexachloride and the methoxy analog of DDT, as well as the pyrethrum-piperonyl butoxide combination, when applied to livestock remain effective against certain species of horse flies long enough to give fairly satisfactory protection.

Research at Summer Lake in Oregon, conducted in cooperation with the Oregon State College, has demonstrated that deer flies are attracted to boards placed upright in the lake. In preliminary tests large numbers of ovipositing females were destroyed when insecticides such as DDT, benzene hexachloride, and parathion were applied to boards that were set up in the lake. This method looks promising for the control of deer flies in this area.

Mice Used as Test Animals

Progress has been made toward perfecting a laboratory method of testing chemotherapeutic agents (internal treatments) for the control of cattle grubs. Larvae transplanted into mice survive long enough to permit tests of injected chemicals, and it has been demonstrated with dyes that a chemical injected into an infested mouse will reach the grub larvae.

A new testing technique has been developed for the preliminary evaluation of insecticides for protecting livestock from stable flies. Mice are treated with the material and later exposed to stable flies in small cages. This method makes it possible to test thousands of materials within a short time, with only small quantities of chemicals that would not be sufficient for tests on livestock.

Toxicity of New Insecticides to Animals

An important phase of studies on new insecticides for the control of livestock pests is a determination of their effect on animals. With funds provided under the Research and Marketing Act of 1946, investigations were undertaken in cooperation with the Bureau of Animal Industry to gain information regarding the toxicity of these materials. Emulsions and wettable-powder preparations of DDT, TDE, the methoxy analog of DDT, chlorinated camphene, and benzene hexachloride (technical grade) were tested on sheep, goats, cattle, swine, and horses. Most of the animals were mature or nearly so. All insecticides were used in 1.5-percent concentration, which is two to three times the strength likely to be employed for the control of even the most resistant livestock pests.

The sheep and goats were dipped, and the other animals were thoroughly sprayed. The treatment was given eight times at 4-day intervals. Chlordane was the only material that produced toxic effects. About half the goats and sheep died, some of them after the

fourth treatment with that material. In further tests 3 out of 10 cattle sprayed with 2 percent of chlordane died after 4 treatments at 2-week intervals. No ill effects were noted on cattle similarly treated with the other chlorinated hydrocarbon insecticides after 10 applications during a 5-month period.

More recent studies indicate that young calves may be poisoned by sprays containing chlorinated camphene. A single application of 1.5-percent spray produced toxic symptoms in several calves 1 to 2 months old, and after a second application two calves died and others showed toxic effects.

Tests with parathion confirmed the reported high toxicity of this insecticide. Goats and sheep died after one treatment in a dip containing 1 percent of parathion. When the concentration was reduced to 0.1 percent, all animals survived three dippings 4 days apart, but some died after the fourth dipping.

CHEMICAL STUDIES OF INSECTICIDES

Analytical Methods for Two New Insecticides

Under the leadership of the Interdepartmental Committee on Pest Control, the Bureau participated in a cooperative program with industry and other Government agencies to develop analytical methods for two of the new insecticides, benzene hexachloride and tetraethyl pyrophosphate. Several physical methods were evaluated for the determination of the gamma isomer in technical benzene hexachloride or formulations of it. Among these was a cryoscopic method, developed by chemists of this Bureau, which is based on measurement of the freezing-point depression produced by the sample in pure gamma benzene hexachloride. The methods of analysis for tetraethyl pyrophosphate are based on separation of this compound from the related ethyl phosphates present in the technical product, followed by hydrolysis of the tetraethyl pyrophosphate to diethyl orthophosphoric acid and titration with standard alkali.

Chemical Composition of Hexaethyl Tetraphosphate

Further chemical investigation of so-called hexaethyl tetraphosphate has shown it to be a mixture containing tetraethyl pyrophosphate as its principal insecticidal ingredient. Other constituents are ethyl metaphosphate and triethyl orthophosphate, both of which are relatively inactive insecticidally. Pentaethyl triphosphate, an unstable compound having some insecticidal value, may also be present, but this has not beeen established with certainty. Pure tetraethyl pyrophosphate hydrolyzes to diethyl orthophosphoric acid.

In the course of the preparation of some sulfur-containing analogs of tetraethyl pyrophosphate, a reaction product of ethyl alcohol and thiophosphoryl chloride was obtained which proved highly toxic to aphids.

Insecticides in Milk and Animal Tissue

Samples of milk from dairy animals that had been treated with various insecticides for horn fly control were tested for the presence of the insecticide. Milk from cows treated with DDT or TDE was tested by a modification of the colorimetric method previously developed by the

Bureau for the determination of DDT. This method has now been refined so that it is possible to detect as little as 0.1 part per million of these materials in milk.

Small quantities of DDT were found in the milk. When a spray containing 0.5 percent of DDT was used, the amount ranged from 0.1 to 2 parts per million. The highest values were obtained a few days after the treatment. By isolating *p,p'*-DDT from the milk of a cow that had received a diet containing large amounts of DDT, it was definitely established that DDT itself, and not some decomposition product, was being determined. The material extracted from the milk of this cow was equally as toxic to flies and mosquito larvae as a sample of the DDT fed to the animal. TDE also appeared in the milk of cows treated with this insecticide, but the largest quantity found was 1.2 parts per million.

To detect the presence of chlordane, chlorinated camphene, and the methoxy analog of DDT, determinations are made for organic chlorine, since no specific tests are available for these insecticides. The results of these tests are not yet complete.

A study is being made to determine the extent to which the new insecticides are deposited in the fat, meat, and organs of treated animals. Preliminary tests with excessive quantities indicate that all the materials are stored in fatty tissues, but quantitative data and results of tests with amounts used in insect-control operations are still incomplete.

The flesh of cattle and swine treated with benzene hexachloride showed no evidence of off-flavor or odor when the dosages and frequency of application were the same as are used for insect control. A few investigators detected such taint when excessive quantities of this material had been used.

Separating Anabasine From *Nicotiana Glauca*

An improved procedure has been developed for the laboratory-scale extraction of anabasine from *Nicotiana glauca*. The ground plant material is treated with ethylene dichloride and ammonia, and the liquid is filtered off, reduced in volume under vacuum, and neutralized with sulfuric acid. Aluminum sulfate solution is added to the neutralized extract to bind the anabasine as a salt and make it water-soluble, and thus separate it from the organic solvent. The aluminum is then removed by precipitation with ammonia as the hydroxide, which is filtered off. The filtrate is reduced in volume under vacuum, and the free anabasine is again extracted with ethylene dichloride and ammonia. From this extract the ethylene dichloride and ammonia are removed under vacuum, leaving the free alkaloid practically pure.

INSECTICIDAL VALUE OF NEW MATERIALS TESTED BIOLOGICALLY

With funds supplied under the Research and Marketing Act of 1946, preliminary laboratory tests were made on a large number of new chemicals of synthetic or plant origin to determine whether they had insecticidal value.

The fluorine analog of DDT was one of the most toxic of 139 ma-

terials tested on house flies, and also of 76 compounds tested on plant-feeding insects and spider mites.

Parathion was found to be about 40 times as toxic as the pyrethrins to flies, and it was effective against all other insects subjected to test, including several mites and aphids, the California red scale, and the celery leaf tier. 2,4-Dinitrophenol and 4,6-dinitro-*o*-cresol also were especially toxic to mites.

Of 86 compounds that were tested for synergistic action with pyrethrins, 20 showed appreciable promise. Of 124 tested similarly for synergism with nicotine, in cooperation with the Bureau of Agricultural and Industrial Chemistry, the best compound was 4,4-dichlorophenyl sulfide.

Studies on the isomers of benzene hexachloride showed that the epsilon isomer is of low insecticidal value. The inclusion of cornstarch in roach tablets containing gamma benzene hexachloride was found to increase the kill obtained with this insecticide.

AEROSOLS AND EQUIPMENT FOR APPLYING THEM IMPROVED

Low-pressure aerosols are finding an important place in household use. The low-pressure aerosols are included in the aerosol patent assigned to the Secretary of Agriculture, and formulas proposed for manufacture are reviewed and accepted by the Bureau with respect to chemical and physical compatibility, as well as to insecticidal effectiveness. Many of the commercial products contain pyrethrum extract, piperonyl butoxide or sesame oil extractives, DDT, and alkylated naphthalenes, with a mixture of trichlorofluoromethane and dichlorodifluoromethane as the propellent gas. They are packaged in cans that are much lighter and cheaper than the heavy containers required for the high-pressure aerosols. Interstate Commerce Commission regulations permit the use of these cans for shipping noninflammable formulations having pressures up to 40 pounds per square inch.

A nozzle for heat-generated aerosols has been developed for use on the engine exhaust of trucks and tractors. The nozzle utilizes the heat of the exhaust to lower the viscosity of the oil in aerosol solutions and the velocity of the exhaust gases to break up the oil. Particle size is determined by the speed of the engine, the rate of flow of the solution, and the constriction at the nozzle.

The performance of several mechanical aerosol generators was tested and found to be satisfactory with respect to particle size. In field tests other commercial aerosol generators were found to give good control of plant bugs on peaches and of Japanese beetles on corn.

Automatic equipment for applying gas-propelled aerosols to airplanes, improved by the Bureau, has been tested in cooperation with the Army and Navy. Such devices can be operated by the pilot and insure the application of the full prescribed dosage and its distribution to all parts of the plane.

BIOLOGICAL CONTROL OF WEEDS SHOWS PROMISE

Shipments of two species of leaf-feeding beetles, *Chrysolina* spp., totaling 500,000, were received from Australia for colonization in northern California, Oregon, and Washington against the Klamath

weed. Many colonies of these beetles released in California in 1945–46 are now well established and are showing definite promise of checking this weed pest.

The first importations of the seed-feeding weevil *Apion ulicis* Foerst., an insect enemy of gorse, were made from England. These weevils are being tested to see whether they will attack field crops before releases are made for the control of gorse.

HONEY BEES AND OTHER POLLINATING INSECTS

Carbon Dioxide Treatment of Queens

Discovery that subjecting virgin queens to carbon dioxide gas causes them to lay eggs marks an important advance in bee breeding. Queens so treated lay drone eggs, but they can later be mated with their own sons to produce a 50-percent-inbred F_1 generation. With this treatment together with artificial insemination closer inbreeding may be accomplished. The development of controlled hybrids will give the bee industry strains of bees high in honey production, strains particularly good for pollinating crops, and strains resistant to disease or adapted to various special requirements.

The carbon dioxide treatment, as well as standard equipment for artificial insemination, was developed by Bureau workers in cooperation with the agricultural experiment stations of Wisconsin and Louisiana. A manual giving information on the artificial insemination of queen bees was issued during the year. This manual describes the instruments used and gives directions for handling queens, including the treatment with carbon dioxide.

In cooperation with the University of Louisiana, a week's course in bee breeding was given to queen breeders and others interested in the technique, particularly of artificial insemination.

Pollinating Insects in Alfalfa and Red Clover

Studies have been continued on the pollinating activity of honey bees and other insects, particularly in alfalfa and red clover.

In alfalfa fields in Utah 1 bee per square yard was the greatest frequency observed early in the blooming period. As flowering increased more bees were counted, until at peak bloom as many as 4 bees per square yard were found in many of the counts. The plots under observation covered 3.2 acres and were visited by about 42,000 bees during the peak of flowering. Pollen collection was almost negligible, however. Only 1 pollen collector was found to about 400 nectar collectors, when there was about 1 colony per acre in the area. The ratio was changed to 1 to 265 when the plots contained 2 colonies per acre. In an attempt to increase the number of pollen collectors, competitive plants were destroyed by mowing and spraying with 2,4-D, but such increases were very slight.

In a 300-acre alfalfa field in California the yield of seed was 30 percent greater close to the hive than one-fifth of a mile away. Fan-shaped dark-brown areas caused by a heavy seed set were conspicuous near the hives. Pollen taken from traps on hives in Utah likewise indicated that the bees work the nearest blossoms. For example, 78 percent of the pollen from colonies placed in an alfalfa field was alfalfa, as

compared with only 34 percent from colonies one-fourth of a mile away. Pollen-plant competitors of first-crop alfalfa were, in order of importance, greasewood, *Iva*, *Dondia*, yellow sweetclover, and burdock.

Wild bees were found to be exceedingly active on one variety of alfalfa but to neglect another variety growing less than 200 yards away. These observations indicate that some varietal difference affects the activity of wild bees in gathering pollen and nectar.

Both chlordane and parathion dusts applied to alfalfa in bloom proved harmful to bees.

In Ohio 79 to 100 percent of the pollinating insects found working on red clover were honey bees, 0 to 18 percent were bumble bees, and 0 to 8 percent solitary bees and other miscellaneous insects. It is estimated that about 1,700 honey bees per acre should be present during the blossoming period to insure the pollination of all red clover flowers.

Feeding 20-percent sugar sirup in open feeders in a red clover field appeared to stimulate the pollinating activity of honey bees. At the time of the experiment heartsease bloom competed with red clover in the forenoons. The bees were active on both the sugar sirup and heartsease at the same time, although the heartsease nectar was of higher sugar content. The sirup was more accessible to the bees, however, and could be gathered more quickly.

Although the cold, wet weather in the 1947 season was unfavorable for bumble bees, nine species of *Bombus* and two species of *Psithyrus* were collected on red clover in Ohio. The first queens emerged in mid-April.

Hybrid Bees Tested

Out of a total of 397 queens of inbred lines that were artificially inseminated, 235 started to lay, and 198 of these queens survived for shipping to other Bureau laboratories for testing purposes.

All the queens from three lines under test for a number of years for resistance to American foulbrood were resistant, but colonies of one line became infected with European foulbrood. Many colonies were severely infected with Nosema in the spring. Some strains that had shown pronounced honey-producing ability in tests in Wisconsin were inferior in resistance to American foulbrood when tested in Wyoming.

Bees Use Cells Containing American Foulbrood

Bees were found to store nectar in cells containing portions of bee larvae killed by American foulbrood (scales). Nectar was observed at least once in 151 of such cells, a second time in 33 of the same cells, and a third time in 1 of them. Pollen was stored in 3 such cells. Among 193 cells that had harbored American foulbrood before being cleaned out by bees, and in which no food had been stored in the meantime, 183 healthy bees were reared. Among 277 cells that were cleaned out but in which nectar was stored before they were used for brood, 259 healthy bees were reared. Brood rearing was attempted in 24 cells while they still contained portions of American foulbrood scales. Bees in 12 cells had reached the late pupal stage when the observations were terminated.

Before storing sugar sirup to which American foulbrood spores had been added at the rate of 500,000 per cubic centimeter, worker bees removed from 50 to 82 percent of the spores. Colonies that were

resistant to the disease removed a larger percentage than susceptible colonies.

Sulfathiazole Does Not Cure American Foulbrood

Sulfathiazole fed in sugar sirup continued to retard the development of American foulbrood, even to the apparent disappearance of disease in the apiary. In a few colonies, however, the disease recurred during the season. It has been definitely shown that sulfathiazole has no effect on the spores of *Bacillus larvae* beyond a possible slowing down of germination. The sulfathiazole treatment therefore cannot be considered a cure. Colonies in which evidence of disease has been eliminated must be considered potential sources of infection.

Plastic Container for Shipping Bees by Air

A container of plastic cloth has been devised for shipping package bees by air. It weighs about one-fourth as much as containers now in commercial use, is more convenient to handle, and is collapsible for return shipment to the package-bee producer for repeated use.

CONTROL OF PLANT DISEASES

White-Pine Blister Rust

Use of 2,4-D Increased

Experimental work in 1946 with 2,4-dichlorophenoxyacetic acid (2,4-D) on the Sierra gooseberry (*Ribes roezli*) in the sugar-pine forests of California showed such a high kill that in 1947 this chemical was used on a practical basis in the field for destroying this host of blister rust. The Sierra gooseberry is the principal species of ribes found in the blister rust control areas of this State. It often occurs in large numbers on portions of the best growing sites for sugar pine. The removal of these thickets by hand grubbing requires from 5 to 10 man-days per acre. In contrast, they can be destroyed with 2,4-D sprays at the rate of about 1 man-day per acre. In large-scale field work power equipment was used to spray the aerial parts of ribes. When large bushes were encountered among rocks or in other situations where digging or spraying was impracticable, they were decapitated at the crown and the freshly exposed surfaces treated with 2,4-D concentrates. These methods were also successful in destroying *R. nevadense*.

During 1947 seven power sprayers were used to apply over 360,000 gallons of 2,4-D aqueous sprays in concentrations of 750 parts per million (acid equivalent) on ribes in scattered areas aggregating 1,550 acres. The number of ribes bushes averaged 1,735 per acre, and the use of 2,4-D is estimated to have saved at least 8,000 man-days of hand grubbing. It also reduced the cost of ribes removal on some of the most difficult areas to that of a normal eradication job. The spray is fully effective only while the plants are in an actively growing stage, and thorough coverage of the foliage is necessary. The spray season in the sugar pine region is therefore restricted to June and July. A double shift of workers was sometimes employed to make full use of power equipment and accomplish as much as possible during the short spray period. After operations were terminated, the

spray equipment was made available to fire-suppression organizations for extinguishing forest fires.

In other white-pine regions the kill obtained with 2,4-D on several resistant species of ribes encountered in control areas was not high enough to warrant its general use in field work. Experimental results with the esters of 2,4,5-trichlorophenoxyacetic acid in an oil diluent are encouraging and hold some promise that a satisfactory chemical will be found for treating ribes resistant to aqueous solutions of 2,4-D. Experiments with 2,4-D concentrates applied under pressure from light hand sprayers indicate the possibility of extending chemical eradication to areas with fewer ribes bushes, where treatment with power equipment is not economically practicable.

More Than 22 Million Ribes Bushes Destroyed in 1947

For the first time since 1941 an adequate supply of labor was available in 1947, and more efficient and stable crews resulted, with far less turn-over. There was also less disruption of work due to fire fighting. The training of workers in the western white-pine region was greatly improved and expedited through the use of large training charts to aid in explaining techniques of the job.

In the calendar year 1947 all cooperating agencies destroyed more than 22,000,000 ribes bushes on 2,000,000 acres. Nearly half of this area represented initial eradication. The total labor required was 234,140 man-days. These accomplishments were about the same as in 1946. Although the acreage worked was slightly larger, the numbers of effective man-days used and ribes bushes destroyed were somewhat smaller.

Owing to a reduction in Federal funds it was necessary to close most of the Bureau camps in August 1947. This premature closing was unfortunate, because during the war years many initially protected areas that needed reworking could not be reached with available facilities. Since then priority has been given to such areas in planning field operations, and continued stress has been placed on rework. Nevertheless, some areas became so badly infected that they had to be abandoned to the disease. At the peak of the season 6,448 persons were employed in ribes eradication, and 106 camps for workers in forest areas were operated.

The protective zones around 15 nurseries, containing over 48,500,000 white-pine trees for planting in forest areas, were reworked, and 2,454 ribes bushes were removed from 7,400 acres. A total of 41,160 infected white pines, mostly in plantations, were saved by cutting off of the diseased portions. At the end of the calendar year 1947 about 12,000,000 acres were on maintenance, an additional 11,000,000 acres had been worked but required further treatment, and 5,000,000 acres had not yet been worked. A total of 27 States, together with counties, townships, timber protective associations, lumber companies, and individuals, cooperated in the work.

Ribes Removal by Contract Shows Promise

Removal of ribes from areas containing relatively few and scattered bushes by contracting the work to private individuals on the basis of competitive bids, which was initiated in 1946, was given a further trial. Cooperating Federal agencies in the sugar-pine sections of California and Oregon awarded 34 contracts for removing ribes bushes from 6,258

acres at an average bid of $6.25 per acre. These contracts were completed in a satisfactory manner at a cost about 39 percent lower than was obtained on comparable areas with labor crews operating out of regular camps. Similar results were obtained from three contracts awarded in the western white-pine region of Idaho for removal of ribes from 245 acres at an average bid of $7.25 per acre. Not only were costs lowered by this procedure, but coverage was more rapid and the work cleaner. These results assure more extensive use of the contract method in field operations and further experimental trials under differing ribes conditions to determine the practical limitations of its usefulness.

Rust Extends Southward in Various Regions

In the North Central States there was a large southward extension of blister rust on ribes. It was found for the first time in 62 counties, 9 of which were in Illinois, 39 in Indiana, 10 in Ohio, and 4 in Michigan. The infection on ribes leaves was light and appears to be the result of long-distance spread of aeciospores from diseased pines in the northern half of the Lake States during periods of favorable weather. A protracted period of drought and heat late in the summer may have prevented the diseased ribes from causing much local pine infection. Diseased pines were reported for the first time from 14 counties—5 in Illinois, 2 in Indiana, 1 in Iowa, 1 in Michigan, and 5 in Wisconsin. The infected trees in Illinois were found in white-pine plantations. The stock used in these plantations was obtained from nurseries outside the State and apparently was infected when planted.

In the southern Appalachians diseased pines were reported for the first time from one county in each of the States of Tennessee, North Carolina, and West Virginia, and from two counties in Virginia. Only one infected tree was found in each of the first three States. In Virginia there were four diseased pines in one county and scattered infections over about 30 acres in the other. These findings did not extend the rust southward beyond the limit of its previously known occurrence.

In the West blister rust was found near Victor, Idaho, on *Ribes petiolare* bushes growing in association with *Pinus flexilis*. This location is in Teton County on the Targhee National Forest. In 1946 the rust was found about 10 miles east of this point in Wyoming, 150 miles south of diseased pines in Idaho.

In the sugar-pine section of California the finding of infected pines on Pilot Creek, Eldorado National Forest, extended the southward advance of the rust 8 miles. Several new centers of infection were found near known diseased areas, but there was no significant change in the distribution of the rust.

The southward advance of the rust in the West from the time of its introduction into British Columbia in 1910 is shown in figure 2.

New Methods of Suppressing Ribes Tried

Ecological studies on methods of evaluating ribes-regeneration potentials, and on the effects of logging, burning, grazing, and plant competition on methods of suppressing ribes, have been completed, and the data obtained are now being used in coordinating plans for blister-rust control and improved management of western white and sugar pine, which is being undertaken in cooperation with the Forest Service.

An experiment in which employees worked alone instead of in crews was tried in the sugar-pine region. By this method responsibility for ribes eradication in a definite area is fixed on one individual. The worker is not forced to adjust his pace to that of other workers as required in crew formations, ribes distribution by species and location can be accurately shown on a map, and progress records can be maintained for each individual, so that poor work can be quicky noted

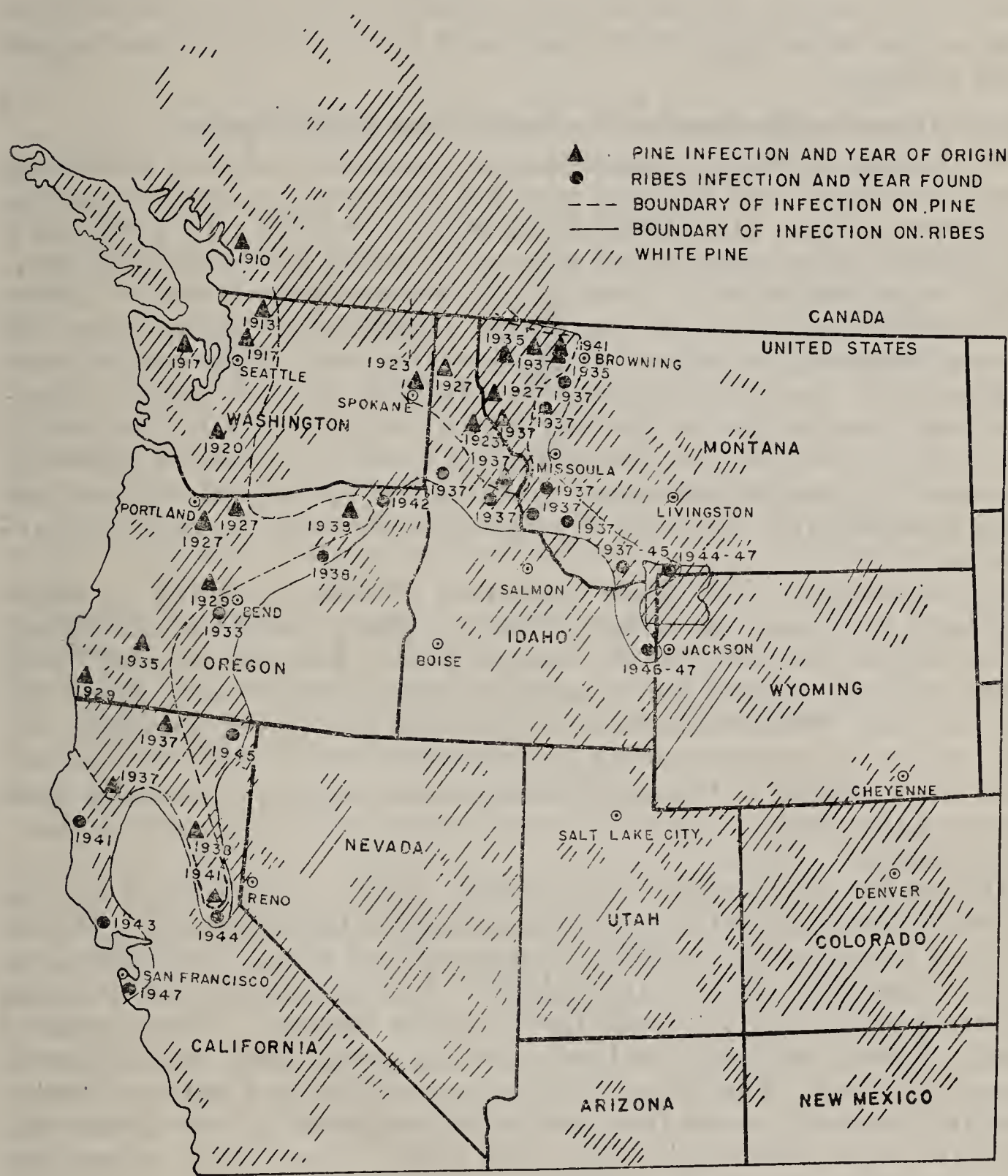

FIGURE 2.—Spread of white-pine blister rust in the West since its introduction in 1910.

and corrected. Disadvantages include inability of some men to work alone, the physical strain of using a dragline for marking work strips, and modifications in established methods of checking. This procedure resulted in increased production and more thorough and efficient ribes removal, and will therefore be given a more extensive trial during the next season.

Stem Rust

Losses From Stem Rust Light

In general, crop losses from stem rust were light in 1947, but serious damage occurred in local areas in Pennsylvania, Virginia, Washington, and West Virginia, where the disease developed early on barberry bushes and spread to the small-grain crop. In a few counties in western Nebraska, southwestern South Dakota, and northeastern Wyoming, inoculum from infection centers in the southern part of the Mississippi Valley arrived late in the season and caused some damage.

Area Cleared of Barberries Protected from Reinfestation

Within the 18 States cooperating in the control of stem rust, more than three-fourths of the land area has been freed of rust-susceptible barberry bushes. It is maintained in this condition by preventing them from being reestablished through planting and subsequent seeding. Such protection is accomplished primarily by nursery inspection and enforcement of quarantine regulations. These activities become increasingly important as more and more of the control area is cleared of susceptible barberries. During the year special attention was directed toward getting all nurserymen to label barberries correctly, to produce and distribute only true-type plants of approved resistant or immune species and varieties, and to use seed that had not been contaminated through cross-pollination with susceptible barberries.

In cooperation with State inspection officials, a survey by questionnaire was made of barberry stock in the nurseries of 22 States, 10 of which were outside the control area. Returns received from 1,228 nurseries showed the location of susceptible barberry stock, the sources from which barberry seed and liner stock were obtained, and the number of nurseries doing interstate business in barberry plants. This information is being followed up by visits to nurseries that are not fully conforming with the objectives of the barberry-eradication program.

During the year permits were granted 53 nurseries desiring to ship barberry plants under the provisions of Federal Quarantine 38. Thirty of these nurseries were within the quarantined area. The inspection work uncovered additional evidence of the danger of importing barberry seed and liner stock from foreign sources. Three consignments of liner stock and one block of stock grown from imported seed were destroyed. The liners included susceptible and untested varieties, and the stock grown from seed which supposedly came from true-type *Berberis thunbergii* plants was badly mixed with susceptible plants of *B. vulgaris* types.

13 Million Barberry Bushes Destroyed in 1947

At the beginning of the 1947 season 50,000 square miles of control area were in need of rework. This work was given first consideration so as to preclude the reseeding of barberries and the extension of the infested territory. In States where the rework was up to date, attention was given to the eradication of bushes in unworked areas and to the periodic reinspection of previously infested sites to prevent reseeding by susceptible bushes that may have developed since the last working.

During the calendar year 1947 more than 13,000,000 barberry bushes were destroyed on 1,660 new and 1,938 reinfested properties. Of the bushes destroyed, 11,500,000 were *Berberis canadensis*, 1,550,000 were *B. fendleri*, and the rest were *B. vulgaris*. *B. canadensis* is confined almost entirely to Virginia and West Virginia, and *B. fendleri* is found in southwestern Colorado. *B. vulgaris* is more widely distributed, occurring in all control States. On 7,909 properties that were reworked no barberry was found, and 2,845 of them were added to the area on maintenance, which will require no further organized crew work. As a result of the year's operations 23,925 square miles were placed on maintenance. Of the properties found reinfested, 59 percent had fruiting bushes, an indication of the extent to which reinspection of previously infested properties was behind schedule.

New Chemicals Tested for Eradicating Barberry

Efforts were continued to find a cheaper herbicide for eradicating *Berberis fendleri* and *B. canadensis*, the two native species of barberry, and for treating planted *B. vulgaris* bushes without endangering nearby shrubbery and trees. More than 400 plots were laid out, on which various formulations and concentrations of 2,4-D and ammonium sulfamate were tested on native barberries. In addition, individual plants of *B. vulgaris* with the canes cut off flush with the surface of the ground were treated with these chemicals in solution and in dry form. Preliminary observations show that *B. fendleri* is susceptible to severe damage by formulations of 2,4-D, principally the esters. *Berberis canadensis* was resistant to 2,4-D, but ammonium sulfamate in solution seemed to give a satisfactory kill. Dry ammonium sulfamate and highly concentrated solutions of 2,4-D killed the crown and roots of *B. vulgaris* in most instances. Further work with these chemicals is needed before recommendations can be made for their general use in the field.

Many Races of Stem Rust Involved in Spread

The physiologic-race complex was determined by processing 792 collections of stem rust. Races 56, 38, and 17 of wheat stem rust constituted more than 93 percent of the isolates, and races 2 and 8 of oat stem rust predominated. Race 7 of oat stem rust, to which such new varieties as Clinton, Benton, Bonda, and Mindo are susceptible, was found only in New York State. The importance of the barberry as a breeding medium for stem-rust races was obvious again this year. The aecial material obtained from barberry plants, on which stem-rust races hybridize, yielded a different race for each two collections. These races were 56, 17, 11, 19, 15, 16, 34, 38, 40, 45, 48, 59, 111, and one entirely new race.

Diseases of Elm

Phloem Necrosis Transmitted by Leafhopper

After 5 years' search an insect has been proved capable of transmitting to elm trees the virus causing phloem necrosis. This insect is a leafhopper, *Scaphoideus luteolus* Van D. It has been found throughout the region where phloem necrosis is known to occur and in several eastern States that are outside this region. This species overwinters in the egg stage. The eggs are laid in the bark of elm trees, and the nymphs, or young, can develop to adults when confined to elm foliage. It is possible that other insects may also be concerned.

Dutch Elm Disease

The Dutch elm disease was found on American elm in Colorado early in 1948. The fungus, together with the smaller European elm bark beetle, was taken from four trees in Denver, and later from trees in four other localities in Colorado—Arvada, Boulder, Longmont, and Greeley. This is the first discovery of the disease west of Indianapolis, Ind.

In the District of Columbia area the first diseased trees since the initial discovery in 1947 were found in May 1948. This year the fungus has been isolated from specimens from six trees near the Capitol, five at scattered locations within 2 miles of the Capitol, and one in Arlington, Va. All but one of the specimens were submitted by National Capital Park officials, although only five were Park trees.

In Tennessee the Dutch elm disease fungus was found in material taken from an elm in the Shiloh National Military Park, but it could not be obtained from additional specimens collected from the same tree a few months later. This is the fourth instance in which trees in Tennessee, once found to be diseased, later gave negative results.

After a 15-year search the perfect, or perithecial, stage of the Dutch elm disease fungus, *Ceratostomella ulmi*, in which it produces sexual spores, has been found on naturally infected wood. Two of the trees from which such spores were taken were in New Jersey and one was in Colorado.

Tests were continued in 1947 to determine the minimum number of applications and the lowest concentration of DDT required to protect healthy elms from feeding by bark beetles that carry Dutch elm disease. About 27,600 gallons of emulsion were applied early in the spring to 1,375 elms on 5 plots at the rate of 20 gallons per tree; on 2 plots a second application was made in midsummer, and 1 plot was sprayed three times. It was found that a formulation containing 2 percent of DDT plus benzene and an emulsifier consisting chiefly of mono- and dimethylnaphthalenes, applied thoroughly in the spring, followed by a 1-percent spray in July, effectively controlled bark beetle feeding. This spray did not cause significant injury to the trees or surrounding plants, to the spray machines or their operators, or to animals.

Mist blowers were used to apply DDT to a small number of large elms. When operated in still air and set to deliver 12-percent DDT emulsion at the rate of 1 gallon per minute, they deposited enough DDT to control bark beetles. More than 1 gallon was required for satisfactory coverage of a large elm.

Citrus Canker Survey Resumed in Texas

The cooperative citrus canker eradication work which had been carried on in the Gulf Coast States for about 30 years was discontinued in 1944. At that time the disease had apparently been eradicated from commercial groves and nurseries in all the infected States, but scattered infections continued to be found in Texas and Louisiana, mostly in hedges and on abandoned and escaped *Poncirus trifoliata* trees. In view of the numerous recurrences of this disease several years after it had apparently been eradicated, there was some suspicion that it might still exist in an incipient stage in Texas.

An additional survey was therefore undertaken cooperatively by this State and the Bureau of Entomology and Plant Quarantine. The work, which was begun in September 1947 and is not yet completed,

includes the location and inspection of all citrus trees on or near properties upon which canker has been found since 1920, and also the inspection of *P. trifoliata* hedges throughout eastern Texas. Nearly 2,000,000 trees have already been inspected on more than 11,000 properties in 63 counties in Texas and 1 county in Arkansas, but as yet no citrus canker has been found.

Spread of Peach Diseases Prevented by Nursery Inspection

Since the present system of cooperative Federal-State nursery inspection for preventing spread of the phony peach and peach mosaic diseases was begun more than a decade ago, there has been no record of these diseases being spread in nursery stock.

In the spring of 1948, 254 nurseries growing more than 4,270,000 trees were inspected within areas regulated by State quarantines. Twenty-seven nurseries growing nearly 20,000 peach trees failed to meet the certification requirements and will be barred from shipping their stock. Beyond regulated areas, in sections where these diseases formerly occurred or in important nursery-stock-producing centers close to infection, 205 nurseries growing more than 11,500,000 stone-fruit trees were inspected as a precautionary measure. None of these nurseries were found with infection in their environs.

Fewer mosaic peach trees were found in the Southwestern States during the past year than at any time since the control program was begun. Less than 4,000 new cases were found, or less than 0.2 percent of the more than 2,000,000 orchard trees inspected. In comparison more than 2 percent infection was found in 1937. The first mosaic tree to be discovered in Arkansas was found and destroyed in 1947. No other infection was found when the property and its environs were reinspected early in 1948. General inspection for mosaic was undertaken there in 1948 and, although the work was not quite complete at the close of the year, no mosaic trees have been reported.

In 7 of the 10 States in which inspection for phony peach disease is now carried on, disease incidence decreased from 13,415 trees in 1936 to 2,756 trees in 1947. Only one infected tree was found in each of the States of Missouri and Tennessee in 1947. Heavy infections occur in portions of Alabama and Georgia. However, inspection and destruction of diseased trees are apparently checking spread of the disease in commercial orchards, and growers are rapidly becoming more conscious of the value of the work.

GOLDEN NEMATODE SURVEY AND INSPECTION INTENSIFIED

The golden nematode survey has been intensified to determine as completely as possible the actual acreage infested in and around the original center of infestation at Hicksville, Long Island. This survey program is carried out cooperatively with the State of New York. During the year 39,977 acres of potato land were examined. The potato roots were inspected on 10,397 acres, but the soil-sample method, effective throughout the frost-free period, was generally used.

At the end of June 1948 the Long Island infestations comprised 6,154 acres on 150 properties, of which 64 acres on 3 properties were in Suffolk County and the rest in Nassau County. This area is still the only known center of golden nematode infestation in the United

States. Special surveys in Steuben County, N. Y., and in the chief potato-growing section of Maine uncovered no golden nematode in either area.

Potatoes grown on 1,579 acres on 35 properties found infested after planting in 1947 amounted to 549,879 bushels. These potatoes were allowed to move under close quarantine supervision for consumption in the New York City area or to authorized alcohol-production outlets. The Bureau assisted New York State in supervising this movement, as well as in enforcing the State's quarantine regulations on topsoil movement, implement cleaning, and other spread-prevention measures.

More than half the area shown by the survey to be infested was withdrawn from production in 1948 under a State compensation program, and about 1,600 acres of infested and exposed land have been diverted into real-estate development.

DOMESTIC PLANT MATERIAL INSPECTED IN TRANSIT

In the enforcement of domestic plant quarantines, transit inspection was carried on at seven permanent and eight seasonal terminals, with the assistance of State collaborators. During the year nearly 1,450,000 shipments were inspected, and 1,746 shipments with destinations in 44 States, the District of Columbia, and the Panama Canal Zone were found to be moving in apparent violation of Federal quarantines. Transit inspectors also cooperated in the enforcement of nursery-inspection and quarantine requirements of the States and the District of Columbia by sending them information in regard to 505 apparent infringements of their regulations.

DISTRICT OF COLUMBIA PLANT-QUARANTINE REGULATIONS ENFORCED

Shippers in the District of Columbia were assisted in complying with State quarantine and nursery-stock regulations by the inspection, treatment when necessary, and certification of 1,033 shipments of more than 55,000 plants consigned to points in 44 States. During the year 30,576 shipments of plants entering the District were examined for certification as to freedom from insect pests and plant diseases. Thirty-three shipments without required certification were intercepted, and several infested shipments were returned to the senders. Inspectors intercepted 22 species of insects, 1 species of nematode, and 7 plant diseases on plants entering or leaving the District.

FOREIGN PLANT-QUARANTINE ACTIVITIES

The safeguarding of our agriculture against the introduction of plant pests continued to be a major problem in 1948. Inspection of ships and airplanes at mainland ports of entry, as well as in Hawaii, Puerto Rico, and Alaska, and of railroad freight and passenger cars and automobiles at the Mexican and Canadian border ports called for increased plant-quarantine services to prevent the importation of pests from foreign countries.

In this work the Bureau had the material assistance of plant-quarantine officers in certain States and of other Federal agencies,

particularly the Bureau of Customs, the Immigration and Naturalization Service, and the Public Health Service. The Departments of the Army, Navy, and Air Force continued their contribution to the quarantine program by issuing directives to prevent the importation of restricted plant material by military personnel.

Carriers and Products Inspected

Several factors contributed to increase the demand for plant-quarantine services at maritime ports of entry. The number of ships inspected was 15 percent greater than during the previous year. Imports of fruits, vegetables, and other agricultural products were larger, particularly since a number of ships engaged in this trade before the war have resumed this service. New vessels built specifically for the transportation of perishables were in use. There was also an increase in plant-quarantine inspection problems associated with passenger travel.

Of 44,330 ships inspected during the year, 24 percent were found to be carrying prohibited agricultural material. More than 90 percent of the arriving ships came directly from foreign ports. Prohibited material was found in 175 of 267 ships arriving from foreign ports via Hawaii, in 27 of 75 ships arriving via Puerto Rico, and in 268 of 806 ships starting from Hawaii and 87 of 483 ships starting from Puerto Rico.

Of 57,756 airplanes inspected at 47 ports of entry, 26 percent were found to be carrying prohibited plant material.

Large volumes of restricted plant materials—particularly fruits, vegetables, cotton products, fibers, cereals, and plant-propagating stocks—were inspected during 1948. More than 271,000,000 crates, boxes, bales, bushels, and other units were inspected. This total does not include the millions of small lots of fruits and vegetables inspected at Mexican border ports of which no record is made.

In Hawaii all aircraft and ships are inspected upon arrival and all planes before departing for the mainland. Airplanes are also disinsectized. The rapid build-up of oriental fruit fly populations on the islands has increased the importance of preflight inspection and disinsectization of all planes destined for continental United States. Almost half of the 5,057 planes leaving Hawaii for the mainland in 1948 were found to be carrying unauthorized plant material. Over 15,000 automobile trunks and pieces of baggage, 47 percent more than in 1947, were inspected and sealed prior to departure for the continent in surface vessels. The movement of fruit and vegetables to the mainland included 4,000 shipments certified after inspection and 139 shipments certified after treatment. Of more than 170,000 packages of cut flowers, including leis, that were examined, nearly 3,300 were refused certification.

In Puerto Rico, another strategic outpost, it has not yet been practicable to undertake preflight inspection of airplanes to the mainland. A total of 737 lots of fruit and vegetables were certified for movement to the mainland.

At Mexican border ports 7,000,000 automobiles carrying more than 2,000,000 pieces of baggage were inspected. Tourist traffic continued to grow as new cars became available, and such traffic constituted a large portion of these totals. The number of freight cars from

Mexico that were inspected was 7 percent greater than in 1947, totaling 73,872. It was necessary to fumigate 8,192 of these cars. The number of pullman and passenger coaches entering the country from Mexico decreased slightly, 3,745 being inspected.

More than 2,000 parcel-post packages from foreign countries were refused entry, in whole or part, out of a total 2,000,000 examined by plant-quarantine inspectors. Over 8,000 packages were diverted to another port for handling, and about the same number were released after inspection. In Hawaii 22,000 express and 75,000 parcel-post packages were inspected, out of 338,000 packages handled. In Puerto Rico about 10,000 parcel-post packages, out of 96,000 handled, were opened for inspection.

A total of 794 lots of plants, seeds, and propagating materials were imported by the Department for experimental purposes. These materials were examined and treated, when necessary, at the inspection house in Washington, D. C. Final inspection prior to release was made of 2,314 shipments of exotic plants grown by the Department under quarantine conditions. Plant materials being grown at plant introduction and propagating gardens maintained by the Bureau of Plant Industry, Soils, and Agricultural Engineering are inspected regularly prior to shipment. Material from the gardens at Coconut Grove, Fla., Mandan, N. Dak., and Chico, Calif., is inspected jointly by Bureau and State officials, and that from the District of Columbia, Glenn Dale and Beltsville, Md., and Savannah, Ga., stations is examined by Bureau inspectors. During the year 4,000 plants, 2,200 budsticks and cuttings, 122,000 roots and tubers, and 2,900 lots of seed were inspected prior to shipment from these gardens.

Plants and Pests Intercepted

Nearly 137,000 interceptions of prohibited or restricted plants and plant products were made during 1948, an increase of 14 percent over the previous year. Such interceptions were made in baggage (99,000), in cargo (6,500), in mail (3,300), in quarters (11,000), and in stores (17,000). Numerous other interceptions were made by customs officers at Mexican and Canadian border ports.

The number of insect and plant-disease interceptions in 1948 totaled about 20,000. They included 8,000 lots of insects and 2,500 of plant diseases in material imported for consumption purposes and 6,000 lots of insects and 1,000 of diseases in material entered for propagation. The remaining interceptions were in in-transit shipments and material found in ships' stores and quarters. These figures include only the more important pests or pathogens. Thousands of noneconomic insects and plant-disease organisms were intercepted but not recorded.

A number of injurious pests were found among 3,500 lots intercepted from airplanes. A few arrived as stowaways, but most of them were found on plant materials. The latter included the citrus blackfly; a bruchid, *Bruchus tristiculus* Fahr.; an avocado seed moth, *Stenoma satenifer* Wlsm.; the West Indian sweetpotato weevil; a pod borer, *Maruca testulalis* (Geyer); the pink bollworm; the Mediterranean fruit fly; the European cherry fruit fly (*Rhagoletus cerasi* (*L.*)); and three other species of fruit flies. Of the interceptions of plant diseases, 60 were on orchids, 67 on miscellaneous flowers and other ornamentals, 7 on citrus fruits, and 38 on miscellaneous food and fiber

plants. Among the disease organisms were a leaf spot fungus of citrus, a stem parasite of snapdragon, lima bean scab, and a rust fungus of vanilla.

Treatment of Imported Plant Material

To insure that injurious pests will not be introduced on imported plant material, fumigation or other treatment is often required as a condition of entry. Nearly 652,000 bales of cotton lint, linters, and bagging, 11,500,000 pounds of cottonseed cake and meal, and more than 19,000 samples of cotton were so treated during the year. Because weevil-infested vetch contaminated the straw bottle jackets, it was necessary to treat 733 cases of liquor. About 37,000 cases of fruits and vegetables; 44,000 containers of chestnuts, cipollini, and pigeon-peas; 29,000 bales of broomcorn; 2,370 containers of seeds; 1,600,000 units of plants, cuttings, bulbs, roots, and other parts of plants; and 24,000 lots of miscellaneous plant products were fumigated or otherwise treated.

Large quantities of military equipment are being returned from islands in the Pacific for use as scrap metal. Much of this material has been found infested with the giant African snail, or to have adhering soil. It has been necessary to supervise the cleaning, fumigation, or other treatment of 340 lots of this equipment.

Ships' ballast contaminated with top soil, vegetable matter, and living insects was fumigated or otherwise safeguarded.

Certification for Export

The demand for plant-quarantine services in connection with the inspection and certification of plants and plant products for export also increased markedly in 1948. To meet sanitary requirements of foreign countries, 9,255 export certificates for more than 5,000,000 containers of domestic plants and plant products, covering 100 commodities, were issued at 36 ports for export to 73 foreign countries.

INSECT IDENTIFICATION A BASIC SERVICE

Accurate and prompt identification of insects is prerequisite to the application of correct control measures. It is also essential for detecting new pests, obtaining knowledge of their origin, determining the distribution of specific pests, and forecasting their abundance. During the year identifications were made of 51,490 insect samples. About half of these samples were submitted by workers in this Bureau engaged in research, control, quarantine, and service activities. The remainder came from other Federal agencies; from agricultural colleges and experiment stations of all States, Puerto Rico, Hawaii, and Alaska; from private institutions, pest-control operators, and individuals throughout the country; and from foreign governmental agencies and institutions concerned with insect control, especially in the Western Hemisphere.

The vast majority of the different kinds of insects, however, are still unknown or are not sufficiently well defined to permit identification. Less than 70 percent of the adult insects submitted for identification and less than 5 percent in the destructive larval stages can be

identified specifically at present. Continuing research in insect classification is essential for improvement of those levels. Such research is conducted intermittently by specialists insofar as service tasks will allow. During the year 42 technical papers, totaling approximately 1,200 pages, on insect taxonomy were published. Among them is a book on the blow flies of North America, a comprehensive work designed to enable definite identification of adults and many larvae in this economically important group of insects.

In addition to conducting direct research continually on problems in the classification of insect groups of economic importance, taxonomists in the Bureau give assistance to workers in certain Federal agencies, colleges and universities, museums, and other institutions who are carrying on research of this general type. More than 150 such investigators were given substantial assistance in research undertakings during the year. The results of all the research, both in the Bureau and outside, contribute steadily to improvement of the insect-identification service.

PARTICIPATION IN FOOD AND FEED CONSERVATION PROGRAM

Informational activities were intensified during the winter and spring when the Bureau participated in the Department's grain-conservation program. Emphasis was placed on the presentation of facts that would encourage and aid farmers and others in conserving food and feed by controlling insect pests.

It is estimated that insects destroy each year about 300,000,000 bushels of stored grains, worth approximately $600,000,000. Most of this loss is borne by farmers, and much of it is preventable by the application of available sound, up-to-date control measures on farms. Food and feed can also be conserved through more widespread use of proper insecticides on livestock for the control of insects and related pests, which are known to waste feed, damage hides, and reduce meat and milk production by nearly half a billion dollars each year. Pests of growing crops, such as the European corn borer, grasshoppers, and insects that damage vegetables or reduce the production of cottonseed, also take a heavy toll of essential supplies of food and feed.

In an effort to reduce such losses, this Bureau, in cooperation with the Office for Food and Feed Conservation and other agencies of the Department, issued information for the use of county agents, farmers, and others, on the latest and best available methods of preventing insect damage to food and feed crops. Various steps that can be taken to reduce these losses were pointed out in a series of nine Fact Sheets. Two of these Fact Sheets concerned control of insect pests of stored grain on the farm; one had to do with the protection of grain in transit; and the others dealt with the control of pantry pests, insects on livestock, grasshoppers in forage crops, the European corn borer, cotton insects, and garden insects. Posters were issued to focus attention on the losses to stored grain and livestock that are caused by insects. Other visual materials included a display panel in color, three large exhibits of the State-fair type, and a one-reel motion picture in sound and color—all relating to control of the European

corn borer. Numerous press releases, feature articles, and Nationwide radio broadcasts also contributed to this program.

Funds from the Department's Office for Food and Feed Conservation were made available to the Bureau in the spring of 1948 to aid the States of Illinois, Iowa, Wisconsin, and Minnesota in enlarging their programs to increase the production of field corn by controlling the European corn borer. Surveys on farms to determine the seasonal development of the borer in relation to the growth of the corn provided information that made it possible for farmers to apply insecticides at the time when they would be most effective in killing the borers and to conserve insecticide supplies by treating only those fields that needed treatment. This program facilitated an exchange of information between Federal and State agencies which led to a better appraisal of the problem and of control procedures, and resulted in the dissemination of pertinent information on how, when, and where to apply insecticides for the practical control of the corn borer in field corn.

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